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Current and programmed Naval Surface Fire Support (NSFS) capabilities are insufficient to execute the Joint Forces Commander's littoral operational missions against a highly advanced regional or near-peer competitor without unacceptable risk. Systemic deficiencies in the requirements generation process have resulted in overlooking major caliber guns as a potential solution for the challenges of long range NSFS to support deep Ship-to-Objective (STOM) maneuver. Failure to solve these deficiencies places strategic, operational and tactical operations at substantial risk. Recommendations are framed in an "ends," "ways," and "means" construct. The history of NSFS, current national strategy, joint and service specific doctrine, current and alternative capabilities associated with providing NSFS are evaluated against current attempts to bridge NSFS gaps with naval aviation and missiles alone. This study will demonstrate a credible case for re-examining major caliber guns and the ships that mount them as part of the NSFS solution set. This thesis identifies five courses of action to meet the NSFS requirements to defeat a future near-peer competitor in the littorals in a timely and affordable manner.

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Naval Surface Fire Support; Naval Gunfire; Battleships; Amphibious; Forced Entry; Littoral Operations, Joint Fires; Naval Fires; Fires; Fire Support; Artillery, 16-inch guns; major caliber gun

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Joint and Interdependent Requirements: A Case Study in Solving the Naval Surface Fire Support Capabilities Gap

by

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Colonel, United States Army

A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning and Strategy.

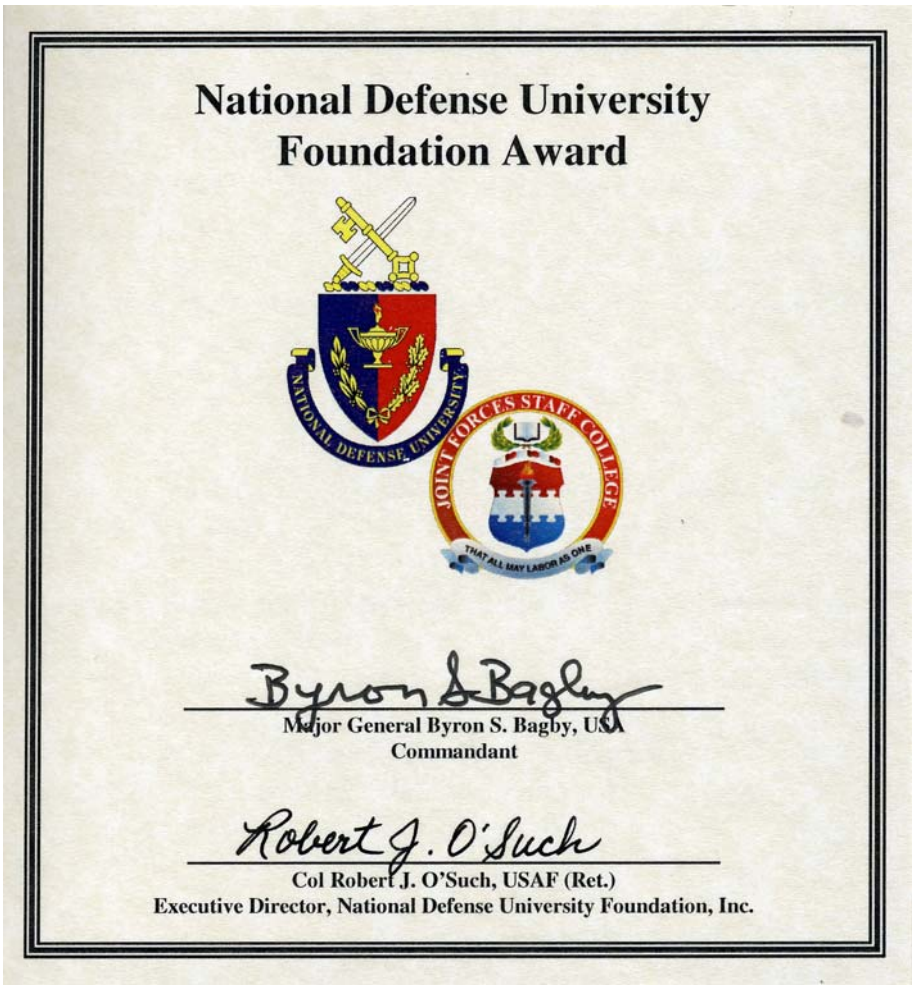
The contents of this paper reflect my own personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.

Signature: 

17 May 2007

Thesis Advisor: Dr. Paul Melshen, Colonel, USMCR (Retired)

This Thesis was presented the NDU Foundation award as the 2007 JAWS Best Thesis.



Thesis Statement

Joint and Interdependent Requirements: A robust Naval Surface Fire Support capability hosted by a Capital Surface Warship is essential for effective littoral forced entry and shaping the Operational Environment to defeat the future near-Peer Competitor in the littorals.

Abstract

Current and programmed Naval Surface Fire Support (NSFS) capabilities are insufficient to execute the Joint Forces Commander's littoral operational missions against a highly advanced regional or near-peer competitor without unacceptable risk. Systemic deficiencies in the requirements generation process have resulted in overlooking major caliber guns as a potential solution for the challenges of long range NSFS to support deep Ship-to-Objective (STOM) maneuver. Failure to solve these deficiencies places strategic, operational and tactical operations at substantial risk. Recommendations are framed in an "ends," "ways," and "means" construct. The history of NSFS, current national strategy, joint and service specific doctrine, current and alternative capabilities associated with providing NSFS are evaluated against current attempts to bridge NSFS gaps with naval aviation and missiles alone. This study will demonstrate a credible case for re-examining major caliber guns and the ships that mount them as part of the NSFS solution set. This thesis identifies five courses of action to meet the NSFS requirements to defeat a future near-peer competitor in the littorals in a timely and affordable manner.

This study was undertaken with the realization that my son, Specialist Adam Lloyd Welch, and son-in-law, Infantry Second Lieutenant Andrew White, may someday require timely, accurate and lethal Naval Surface Fire Support – the kind of fire support that comes only from a gun. It is my desire that this study stimulates serious action to create a viable and effective naval fire support capability within our Navy to support Soldiers and Marines.

This study could not have been written without the unfailing support of my wife Diane. She endured my long hours, often stretching over entire weekends. She then undertook the painful job of editing this study. Anyone who thinks a soldier's wife does not sacrifice for her husband knows not the Army Wife.

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Many people and organizations have provided assistance, advice, and direction in the production of this study. First, I extend my sincerest gratitude to Sue Quensel and Douglas Harrison of Tec-masters, Inc., Lawton Oklahoma office (http://www.tecmasters.com/ModelingSimulation.html), and Lieutenant Colonel Chris (USA) Niederhauser, Fires Battle Lab at Fort Sill for offering to conduct a FireSim XXI simulation to test the thesis of this study. I am especially indebted to Susan Quensel for her work creating the "capital surface warship" and its weapons within the simulation, and then spending hours helping me understand the output. Dr. Alan Zimm of Johns Hopkins University Applied Physics Laboratory spent countless hours advising and critiquing my research, then reviewing the output of the FireSim XXI simulation. Kathy Luft and her Artillery Team at the U.S. Army Materiel Systems Analysis Activity ensured the munitions modeled in FireSim XXI had accurate lethality characteristics. Additional thanks go to General Paul X. Kelley, the 28th Commandant of the Marine Corps, Admiral (USN, Retired) Harry D. Train, Charles E. Myers, former Director for Air Warfare, Office of the Secretary of Defense, FCCM (SW) (USN, Retired) Stephen Skelley, Lieutenant Colonel (USA) Brad Herdon, John Horn, Jon Millner, and Richard Ringler of US Army Training and Doctrine Command (TRADOC), Samuel Loring Morison, Robert Sullivan, James B. Edwards, Colonel (USMCR) Mark Cancian, Russell Hill, Eric Duncan, Jerry Wyant, John Muerdler, Commander (USN) Bryan Clark, Jack Sterling, Captain (USN, Retired) Brian Schires, Chris "Saint" St.George, Colonel (USA, Retired) Michael Fitzgerald, Lieutenant Colonel Robert E. White, Captain (USN, ret) Coenraad van der Schroeff, Thomas E. Doran, Leonard Wilson, Donald Jennings, Robert Lillard, Nathan Okun, Dr. Dennis Reilly, Major (USMC) Robert Washington, Lieutenant Commander (USN) Chris Inskeep, Steven Kienzle, Captain (USN, Retired) Douglas Cassidy, Lieutenant Colonel (USA, Retired) Dan Dall, and others too numerous to list. Some of those who have assisted do not support the findings of this study, but all gave willingly and critiqued my analysis and findings with vigor and camaraderie. All errors and/or omissions are the author's alone.

Critical to this document was the support of the Faculty at the Joint Forces Staff College and the Joint Advanced Warfighting School (JAWS). First, my advisor, Dr, Paul Melshen (COL, USMCR, Retired) endured at least six separate draft reviews, wading through my grammar and making sure my numbers equaled my statements. Lieutenant General (USAF, Retired) Charles Cunningham helped crystallize the strategy-resource discussion. Captain (USN) Shannon Hurley provided much needed polish and focus. Dr. Gail Nicula and her staff at the Ike Skelton Library were indispensable. Dr. Nicula provided structure insight that greatly refined the thesis message. Within her staff, Areena Lowe sought and obtained the most obscure and technical of documents, and Denise Kuykendall secured classified documents and supported declassification down grade requests to various agencies and offices. The College's security manager, Deborah Scavone proved indispensable at obtaining requested declassifications.

Of my classmates, I must thank Colonel (USA) Robert A. Warburg, Lieutenant Colonel (USMC) Timothy Mundy, Lieutenant Colonel (USMC) Michael Mahaney, Commander (USN) Robert Rasmussen, Lieutenant Commander (USN) Michael Luckett, Lieutenant Commander (USN) Chris Senenko, Major (USA) David Gardner, and Major (USAF) John "Speedy" Klein for their time in reviewing and fine tuning this document.

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""The kind of fire support that the Marines need for maneuver ashore in the littorals is not the tactical Tomahawk, it's the kind that comes from a gun….we don't have it [even though] the requirements have been articulated. … We have a hard requirement for a gun. We are not going to fall off from that requirement."

- LTG Emil Bedard, USMC Deputy Commandant for Programs[1]

Introduction

Naval Surface Fire Support is a joint requirement where one service (Navy) provides a capability to support two other services (Marines and Army). Robust NSFS provides greatly enhanced capability to shape the operational environment and defeat a future near-peer competitor in the littorals. However, there is a resource gap in the Naval Surface Fire Support (NSFS) capabilities portfolio for the Joint Operating Concept.

This study applies a cost, risk and benefit analysis approach to NSFS and the Capital Surface Warship. Bartlett and Holman provide a framework using Goals (ends), Strategy (ways), Tools/Resources (means) and Risk to underpin this approach. This construct is a circular decision loop that is directly influenced by resource constraints (means) and the security environment.[2] Risk is assessed against the three pillars – ends, ways and means. Harry Yarger clarifies this by stating "risk is determined through an assessment of the probable consequences of success and failure."[3] This framework is applied in the conclusion to recommendations to close the gap in NSFS capability.

The U.S. Navy currently provides NSFS capabilities and effects using 5-inch guns, missiles and aviation delivered ordnance. The United States Marine Corps has stated this is insufficient.[4] The foundation of this study addresses how to ensure an operationally and cost efficient NSFS capability is developed and fielded within the fleet.

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[1] Sandra I. Erwin, "Marines Clamor for Long-Range Artillery at Sea," *National Defense*, January 2002.

[2] Henry C. Bartlett, , G. Paul Holman, Jr. and Timothy E. Somes, "The Art of Strategy and Force Planning," in *Strategy and Force Planning*, Dr. Richmond M. Lloyd, eds. (Newport, RI: Naval War College Press, third edition, 2000), 19-21.

[3] Harry R. Yarger. *Strategic Theory for the 21st Century: The Little Book on Big Strategy* (Carlisle, PA: U.S. Army War College, Feb 2006), 70-71.

[4] Secretary of the Navy, *Report to Congress on Naval Surface Fire Support*. (Washington, DC: Department of the Navy, 4 April 2006), Commandant of the Marine Corps Attachment, 1-5; Sandra I.

This study analyzed available data which when considering a near-peer competitor provided strong support that: (1) NSFS historically has been a critical littoral combat capability; (2) current and programmed NSFS capabilities are inadequate; (3) past successful systems have not been adequately evaluated, developed and fielded; (4) a mix of major caliber guns, smaller caliber guns, missiles and aviation create the most operationally and cost effective solution to meeting the shortfall; (5) the current analytic approaches have moved the bulk of the NSFS mission to aviation; (6) aviation is the most costly approach to NSFS; and (7) Marine Corps NSFS requirements are not generally accepted by the Navy.

The available data indicates five general options for expanding NSFS capabilities; (1) continuing the current program which builds seven DDG-1000 land attack destroyers and adds a 12th aircraft carrier in 2019; (2) build an additional (13th) aircraft carrier and 24 DDG-1000 land attack destroyers; (3) build four commercial hull based fire support or weapons ships; (4) build four Capital Surface Warships by 2025; or (5) build four Capital Surface Warships and bridge the design and construction time with two modernized *Iowa* class ships. There are additional combinations of options, however to keep the study to a reasonable length, they are not included.

This study considered material available up to February 2007, with the exception of Joint Capabilities Integration and Development System (JCIDS) data which was analyzed through December 2005. *Iowa* class ships and 16-inch guns are assessed as an existing system to provide a baseline of data for comparison in assessing the Capital Surface Warship and major caliber guns (12-inch and larger guns).

Erwin, "Navy Artillery: No New Weapons on the Horizon." *National Defense*; Mar 2006; pg. 23; James W. Hammond, III.. "NSFS Shortfalls." *Marine Corps Gazette*; March 2006; pg. 31.

Chapter 1: Doctrine, History and Current Status of Naval Surface Fire Support (NSFS)

An overview of the employment history of NSFS will demonstrate how historically the U.S. Navy has provided effective NSFS during previous conflicts.[5] Current joint and service doctrine, looming future threats and current challenges as outlined in the following chapter show a continuing need for robust NSFS.

Potential threats requiring action in littoral operational environments: Several locations around the world may likely require forced entry littoral operations. Specific war plans are classified and beyond the scope of this study; however, insight into potential future forced entry or other types of littoral operations is possible by a review of current national strategy documents and recent activities by potential adversaries such as China, North Korea and Iran (see note).[6]

National requirements for littoral forced entry and naval fire support and growth of a near-peer competitor: A review of national strategy documents indicates the United States desires to maintain the capability to execute forced entry operations.

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[5] In 1943 the U.S. Navy had four cruisers off Salerno to deliver naval fires that stopped a major Nazi armored counter-attack. See Major General Donald M. Weller (USMC, Ret), *Naval Gunfire Support of Amphibious Operations: Past, Present, and Future* (Dahlgren, VA: Naval Surface Weapons Center, October 1977), 62; In 1944 Royal Navy and U.S. Navy battleships, cruisers and destroyers at Normandy destroyed Nazi defenses and defeated armored counter-attacks. See Samuel Eliot Morison, *History of United States naval operations in World War II, Volume X: The Invasion of France and Germany* (Atlantic, Little and Brown, Boston, MA: Reprinted 1974), 168-169; At Hungnam in December 1950 the USS Missouri and other warships stopped enemy counter-attacks. Cruisers and destroyers engaged and destroyed enemy defenses. See Weller, 142; The amphibious feint during the Persian Gulf War benefited from the fires of two U.S. Navy battleships, enabling the coalition forces to keep Iraqi troops tied to the coast. The two battleships were the only American vessels capable of providing fire support. See U.S. Department of Defense, *Conduct of the Persian Gulf War* (Washington, D.C.: Department of Defense, April 1992), 251-253, 293.

[6] "Reports on new Iranian missiles tested in naval exercises," *BBC Worldwide Monitoring*, 4 April 2006; "The Iranian missile threat," *The Washington Times*, 10 Nov 2006; "The Next Gulf War?" *Investor's Business Daily* (National Edition), 4 April 2006; "Taiwan President Vows To Pursue "Three Difficult Tasks In Remaining Term," *Financial Times Information Limited*, 3 November 2006; Michael Bruno, "Pentagon doubling equipment for North Korean scenario," *Aerospace Daily & Defense Report*, 215 no. 5, (8 July 2005), 6; Michael Bruno, "Key House Dems scuttle appropriations as leverage," *Aerospace Daily & Defense Report*, 220 No. 15 (23 October 2006), 5; "Kim Jong Il goes ballistic," *The Economist*, 8 July 2006; These articles report on Iranian naval exercises which demonstrated increased capability and reported China continues to state it will not rule out force in its quest absorb Taiwan. North Korea launched ballistic missiles, and the U.S. increased propositioned equipment stocks, indicate a concern for possible war in North Korea.

One such document, the Quadrennial Defense Review Report (QDR), identifies threats in the Pacific from China.[7] Specifically addressed is China's growing ability to project power outside its borders. Advanced capabilities such as integrated air defense systems, torpedoes and advanced submarines increase Chinese capabilities for initiating forced entry and denial of access to U.S and coalition forces.[8] The United States desires to "secure strategic access and retain global freedom of action."[9] Compounding this situation, tensions between China and Taiwan continue unabated.[10] A credible United States presence and forced entry capability could avert conflict or enable decisive reaction to an overt attack.

The National Military Strategy (NMS) states up front the U.S. must "Secure Strategic Access and Retain Global Freedom of Action."[11] Within the NMS, four Joint Operating Concepts are defined, one of which is Major Combat Operations.[12] The Capstone Concept for Joint Operations (CCJO) provides the overall guidance for the Joint Operating Concepts and identifies "regional, near-peer and emerging global competitors" as being able to "gain an advantage against our forces" in the future.[13] The Major Combat Operations Joint Operating Concept (MCO JOC) outlines the need for

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[7] U.S. Department of Defense, *Quadrennial Defense Review Report* (Washington, DC: Department of Defense, 6 February 2006), 29. "Of the major and emerging powers, China has the greatest potential to compete militarily with the United States and fi eld disruptive military technologies that could over time off set traditional U.S. military advantages absent U.S. counter strategies".

[8] Bill Gertz, "China sub secretly stalked U.S. fleet," *The Washington Times*, 20 November 2006, A01; Chris Johnson, "Navy, Analysts Downplay Kitty Hawk Encounter With Chinese Sub," *Inside the Navy*, Vol. 19 No. 46, 20 November 2006; Minnie Chan, "Beijing cements warship ambitions; U.S. embassy shocked by model of aircraft carrier that points to interest in Nimitz-class craft," *South China Morning Post*, NEWS; 17 December 2006, 7.

[9] *Quadrennial Defense Review Report*, 29-31 and A-6.

[10] Peter Enav, "Taiwan and China at war the ultimate nightmare for the U.S., East Asia and the world," The *Associated Press*, 12 August 2006; Huang Jaw-pyng and Deborah Kuo, "Taiwan Allies Complain Of U.N. Neglect Of Taiwan Strait Dispute," *Central News Agency – Taiwan*, 8 September 2006; "A frank examination of a looming catastrophe," *Canberra Times (Australia)*, 3 June 2006. All of these articles indicate tensions are high between China and Taiwan and that conflict can not be ruled out.

[11] Chairman, Joint Chiefs of Staff. *The National Military Strategy of the United States of America* (Washington, DC: Department of Defense, 2004), 1.

[12] Ibid., 9.

[13] U.S. Joint Chiefs of Staff, *Capstone Concept for Joint Operations (v 2.0)* (Washington, DC: GPO, 2005), 9.

forced entry capabilities. Two MCO JOC documents were produced, one in 2004 and the other in 2006. Forcible Entry is cited thirty seven times in the 2004 document, but only twelve times in the August 2006 draft. Both state the U.S. must be prepared now to execute forced entry anti-access operations, as well as maintain strategic and operational preparedness with joint interdependence among service capabilities and associated force structures.[14] The 2006 draft of the MCO JOC states U.S. forces must be prepared to "use forcible entry operations when required."[15] The U.S. must develop and maintain joint assured access capabilities to include expeditionary forcible entry. Offshore naval fires are identified as one of the required capabilities.[16] The draft MCO JOC from 2006 identifies "Littoral Fires" as opposed to "Naval Fires."[17] Forced entry as envisioned by both MCO JOCs requires speed and lethality. Forces must get ashore quickly, with a limited logistics footprint, and accomplish the mission. Forces must be fully supported by deep-reach precision fire support including sea-based and long-range aerospace components capable of type-target discrimination, time-sensitive targeting and in-flight retargeting of smart weapons. This requires a broad range of platforms and weapons systems. The Seabasing Joint Integrating Concept (JIC) nests with the MCO JOC and states that "Naval Fire Support" originates from the Seabase, and then nests them with Joint Fires by stating:

> Joint fires assets are an integral part of Seabasing, and include OAS from sea-based and theater/global aviation assets, and NFS from ships. Future joint fires must provide the

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[14] U.S. Joint Chiefs of Staff, *Joint Operating Concept Major Combat Operations* (Suffolk, VA: Joint Forces Command, September 2004), 12, 22. Hereafter cited as "JCS, *JOC Major Combat Operations* (2004)." This JOC applies to the most recent analysis of NSFS requirements. As of this writing it is under revision with version 2 draft published in July 2006. This JOC states "…most major combat operation cases will require a forcible entry operation or set of operations to set the right conditions for major combat."

[15] U.S. Joint Chiefs of Staff, *Joint Operating Concept Major Combat Operations (Draft)* (Suffolk, VA: Joint Forces Command, July 2006), E-3. Hereafter cited as "JCS, *JOC Major Combat Operations* (Draft 2006)."

[16] JCS, *JOC Major Combat Operations* (2004), 33.

[17] JCS, *JOC Major Combat Operations* (Draft 2006), C-8, C-13. This de-emphasizes the source of fires in littoral operations.

> reach, precision, volume, and responsiveness required to support maneuver forces ashore.[18]

While the 2004 MCO JOC does state that the preferred method of entry is to go where the enemy is not or does not expect us, it also states that the U.S. must be ready to conduct forced entry.[19] The 2004 MCO JOC postulates requirements for 2015 against two of three classes of opponents. The third and most dangerous case, the near-peer competitor, is not envisioned until after 2015.[20] At current rates, the Chinese navy could surpass the U.S. Navy in size by 2015.[21] The Chinese plan to acquire an aircraft carrier by 2010.[22] The 2004 MCO JOC states the near-peer competitor case as the most dangerous and therefore requires new capabilities.[23] The 2006 MCO JOC is silent on cases two, major irregular combat and three. The U.S. must determine the best options or "ways" to deliver NSFS considering cost or "means," effectiveness and flexibility to combat a near-peer or a more capable regional competitor than recently encountered.

Joint Doctrine: No less than six documents devote considerable thought and guidance to the management and execution of amphibious and littoral operations. Joint Fires, the subset Naval Surface Fires, and its subset of Naval Gunfire Support are all

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[18] U.S. Joint Chiefs of Staff. *Joint Integrating Concept: Seabasing (v 1.0)* (Washington, DC: GPO, 2005), 19, 32.

[19] JCS, *JOC Major Combat Operations* (2004), 48-54, and 57-58.

[20] Ibid., 2-3, 65. The July 2006 draft MCO JOC does not identify "near-peer competitor" as an opponent category.

[21] Congressional Research Service. *China Naval Modernization: Implications for U.S. Navy Capabilities – Background and Issues for Congress* (Washington, DC: Library of Congress, 2 June 2006), CRS-1, CRS-5, CRS-6, CRS-15, CRS-19. China's interest in aircraft carriers, growth in amphibious warships, anti-air and anti-ship missiles, submarines, and exercises with Russia aimed clearly at amphibious assault on Taiwan all indicate a goal of near-peer competition from China within the next 15 to 20 years.

[22] Chinese admiral states the intent to have an aircraft carrier by 2010. See Peter Brookes, "China may want to rule the seas: Pacific power play in the works," *Boston Herold.com*, 21 March 2007, accessed 29 March 2007 at http://news.bostonherald.com/editorial/view.bg?articleid=189819.

[23] JCS, *JOC Major Combat Operations* (2004), 3. The JOC states "the sheer scale of a peer changes the character of the fight. As a result, developing the capabilities identified in this version of the concept will not provide all of the capabilities needed to address either Case Two or Case Three." The JOC identifies three cases to plan for, with Case Three being the near-peer competitor. Case One is the high-end regional competitor. Case Two is major irregular combat. Case Three "is not anticipated within the time frame of focus and will be the last of the three developed." The July 2006 Draft MCO JOC does not identify planning for a near-peer competitor.

identified within doctrine publications. Several Joint Doctrine publications directly address Naval Surface Fire Support. Joint planning guidance specifies how to establish command and control and execute an amphibious forced entry operation.[24] Joint Publication 3-02, *Amphibious Operations*, addresses all the facets and planning requirements of amphibious operations, to include an entire chapter dedicated to fire support planning and execution (Chapter VII). Significantly, it states the new focus on amphibious operations launching from "over the horizon" will likely reduce available naval surface fire support –specifically reducing the availability of naval gunfire.[25] This appears to be at odds with ensuring support is provided to the ground force when it is at its most vulnerable during the early forced entry phases when the ground force lacks its own organic fires. While there is contradiction within the doctrine documents, littoral forced entry is seen as a necessary tool in the joint commander's toolbox. A good example is the use of the amphibious feint in Operation Desert Storm were 16-inch gunfire gave it credibility.[26] Naval surface fire support is critical for littoral operations.

Joint Fire Support ("Joint Fires"): Increasingly the term "joint fires" is used in place of Naval Surface Fire Support. Joint Publication 3-0 defines "joint fire support" as including but not being limited to:

> …the lethal effects of air support by fixed- and rotary-wing aircraft, naval surface fire support, artillery, mortars, rockets, and missiles, as well as non-lethal effects of some electronic attack actions and space control operations, as well as other non-lethal capabilities.[27]

Joint Publication 3-02, *Amphibious Operations*, defines Naval Surface Fire Support as:

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[24] U.S. Joint Chiefs of Staff, *Joint Publication 5-00-2; Joint Task Force Planning Guidance and Procedures* (Washington: Joint Chiefs of Staff, 13 January 1999), II-7 and II-8.
[25] U.S. Joint Chiefs of Staff, *Joint Publication 3-02; Amphibious Operations* (Washington: Joint Chiefs of Staff, 19 Sept 2001), III-2, XIV-7 and XIV-8.
[26] U.S. Department of Defense, *Conduct of the Persian Gulf War* (Washington, D.C.: GPO, April 1992), 123, 269, 270, 319.
[27] JCS, *Joint Publication 3-0; Joint Operations*, III-19.

> Fire provided by Navy surface gun and missile systems in support of a unit or units tasked with achieving the commander's objectives.[28]

Service Concepts and Doctrine: The U.S. Navy's "*Naval Operating Concept*" (NOC), issued in 2002, contains concepts that apply to forced entry in general and amphibious warfare in particular. Interestingly, the NOC postulates that the Navy's new strategies of "Operational Maneuver from the Sea" (OMFTS) and "Ship to Objective Maneuver" (STOM) will focus on using the sea as maneuver battlespace and taking objectives inland without the necessity to stop en route to the objective to "seize, defend, and build up beachheads or landing zones."[29] The NOC also states that "Naval forces will conduct forcible entry operations to secure the necessary area and infrastructure, enabling the introduction of additional joint or multinational forces," as well as conducting traditional amphibious forced entry when required.[30] The NOC further clarifies future naval fire support will "include ships with the new advanced gun system like the DD(X) that would provide organic naval surface fire support capability."[31] This increased firepower in the future will support amphibious forces for larger scale conflicts or high threat scenarios from NSFS systems that are networked and integrated, yet dispersed.[32] This is further reinforced in the Navy manuals for amphibious operations.[33]

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[28] JCS, *Joint Publication 3-02; Amphibious Operations*, GL-10.

[29] U.S. Department of the Navy, *Naval Operating Concept (NOC)* (Washington, DC: GPO, 2002), 3. A revised NOC was published in 2006. The new NOC states the Navy will use amphibious operations in Expeditionary Power Projection as deterrence and during counter terrorism. While fires are only mentioned once and in a "strike" capacity, they are required for the amphibious forced entry operations. See U.S. Department of the Navy. *Naval Operating Concept for Joint Operations* (Washington, DC: GPO, 2006), 13, 15, 29-30.

[30] *Naval Operating Concept (NOC)* (2002),,5, 14.

[31] Ibid., 8. U.S. Government Accountability Office. *DEFENSE ACQUISITIONS Challenges Remain in Developing Capabilities for Naval Surface Fire Support, GAO-07-115* (Washington, DC: United States Government Accountability Office, November 2006), 20. Hereafter cited as "*Challenges Remain in Developing Capabilities for Naval Surface Fire Support*." DD(X) has since been renamed DDG-1000.

[32] *Naval Operating Concept (NOC)* (2002), 8, 14.

[33] U.S. Department of the Navy. *Naval Tactics and Techniques and Publication 3-02.2: Supporting Arms Coordination in Amphibious Operations* (Washington, DC: Department of the Navy, May 2004); U.S. Department of the Navy . *Naval Warfare Publication 3-09.1: Navy Strike and Fire Support* (Washington, DC: Department of the Navy, July 2005); U.S. Department of the Navy. *Naval Warfare Publication 3-20.32: Surface Ship Gunnery* (Washington, DC: Department of the Navy, March 1996).

While OMFTS and STOM postulate operations that will try to avoid forced entry amphibious operations, the Navy states it intends to maintain the ability to support forced entry capability. The 2006 NOC cites forced entry once and indirectly connects it to amphibious operations.[34] Much of the focus of the 2006 NOC is the Global War on Terrorism. Within the 2006 NOC, forced entry amphibious operations and related NSFS capabilities are not clearly stated. In contrast, the Army NSFS expectations in the littorals are outlined in FM 3-0, *Operations* as follows:

> Maritime power projection covers a broad spectrum of offensive naval operations. Those most important to Army force operations include employment of carrier-based aircraft, lodgment by amphibious assault or maritime pre-positioned deployment, and naval bombardment with guns and missiles.[35]

These expectations are critical, given that the Army has reduced available organic fires on the expectation that joint fires, to include NSFS, will be available when required.[36]

Past History of NSFS: In conflicts of the past, viable and effective Naval Surface Fire Support has been critical to forced entry and other operations in the littorals. These include operations such as the Normandy Invasion (1944), Pacific Campaign (1942-1945), Korean conflict (1950-53), Vietnam Conflict (1965-1973) and the Persian Gulf War (1990-1991). Many books and documents provide great depth and detail to the contributions made by naval fires in these conflicts.[37] Between the Vietnam conflict

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[34] *Naval Operating Concept for Joint Operations* (2006), 13.

[35] U.S. Department of the Army, *FM 3-0, Operations* (Washington DC: United States Army, 14 June 2001), 2-8.

[36] U.S. Department of the Army, *Field Manual Interim 3-09.42: HBCT Fires and Effects Operations* (Washington, DC: United States Army, April 2005), 8-1. "The HBCT has limited organic fire support assets and relies heavily on joint fires and reinforcing fires provided by a fires brigade when available."

[37] The impact of naval fire support overall to the Normandy invasion is well described from the German perspective. General von Rundsted stated after the war "besides interference from the Air Forces, the fire of your battleships was a main factor in hampering our counterattacks. This was a big surprise, both in its range and effect." Rommel also stated that "...the effect of heavy naval guns.... is so immense that no operation of any kind is possible in the area commanded by this rapid fire artillery, either by infantry or tanks." See Samuel Eliot Morison, *History of United States Naval Operations in World War II, Volume X:The Invasion of France and Germany* (Atlantic, Little and Brown, Boston, MA: Reprinted 1974), 168-169; The ability of major caliber guns to destroy fixed targets, excavate deep earthworks and caves, and

and the Persian Gulf there were two main applications of naval fire, the Falklands Islands and Beirut.[38] This study will expand briefly on the role of NSFS in the Persian Gulf War

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otherwise completely destroy fortifications is well documented. For many examples of the lethality of naval fire support in support of ground troops in the Pacific, see Samuel Eliot Morison, *History of United States Naval Operations in World War II, Volume XXV: Victory in the Pacific* (Boston, MA: Little and Brown, 1960), 40-41 and 48-49; The effect of naval fire support was significant in the Korean war, from tactical support of troops ashore to attacking operational logistics targets. Most notable is destruction of bridges, tunnel entrances and railroads. Railroad destruction also included the ability of major caliber shells to move topography and cause landslides that buried the railroad tracks. Coordinated air-gun strikes are cited as very effective. 16-inch was the best fortification buster, and that 5-inch guns were generally ineffective on field fortifications. 5-inch was cited as most effective on troops in the open or in trenches. See John C. Riley, ed., *Operational Experience of Fast Battleships: World War II, Korea, Vietnam* (Washington DC: Naval Historical Center, 1989), 123-189; Also see John C. Riley, 191-215; The Naval Historic Center provides a wealth of information on the internet addressing naval fires. A series of photos are dedicated to the work of the heavy cruiser USS *Helena* that with ten rounds of 8-inch HC, dropped two bridge spans at Kanggu Hang, 23 miles north of Pohang on 9 September 1950. These photos record a impressive achievement of accurate long range shooting. Accessed on 20 February 2007 at http://www.history.navy.mil/photos/events/kowar/50-nkof/nk-3.htm; During the Vietnam Conflict from May 1965 to June 1968, U.S. surface warships fired over 1.152 million rounds of ammunition. One destroyer fired over 48 tons of ammunition in a 48 hour period – over 1,300 projectiles. The barrels of the USS *Boston*, an 8-inch gun cruiser, were worn nearly smooth. Secretary McNamara announced that heavy cruisers due to be decommissioned would stay on the gun line. This proved critical when the heavy cruisers USS *Canberra* and USS *Newport News* gave sustained support to ground forces combating the enemy's Tet Offensive. In her last tour before decommissioning in 1970, the USS *Saint Paul* fired 3,000 rounds of 8-inch projectiles. The USS *New Jersey*, during her one deployment in 1968-69 fired over 1,200 16-inch projectiles – proving especially effective in counter battery fire against North Vietnamese Artillery. During the 1972 Easter Offensive, naval gunfire played a significant role in isolating North Vietnam from communist support. An example is the USS *Newport News* firing on targets at Haiphong harbor on 10 May 1972. See Malcom Muir, Jr. *Black Shoes and Blue Water: Surface Warfare in the United States Navy, 1945-1975* (Washington, DC: Naval Historical Center, 1996), 162-165, 204; The North Vietnamese held back forces during the 1972 Easter Offensive out of fear of a U.S. amphibious attack. During the 1972 Easter Offensive the U.S. Navy had three cruisers and thirty eight destroyers on the gun line. In their own published history, the Vietnamese cite that due to extensive B-52 and naval gunfire strikes "our troops encountered many difficulties in maintaining their supplies", making the fighting "very complicated". See Lewis Sorley, *A Better War: The Unexamined Victories and Final Tragedy of America's Last Years in Vietnam* (NY: Harvest Books, 1999), 323-324, 326-327, 333; All of the following sources address the success of naval fire support, and specifically state that 16-inch gunfire was the only effective Naval Surface Fire Support provided during the campaign. See U.S. Department of Defense, *Conduct of the Persian Gulf War* (Washington, D.C.: Department of Defense, April 1992), 259-263, 273-274, 293, 396, 451, 807, and 869-870; Vice Admiral Stanley Arthur,. "Desert Storm at Sea." U.S. Naval Institute Proceedings, Naval Review 1991, 82; LtCdr Michael C. Braunbeck, "Front Line Lessons." U.S. Naval Institute Proceedings, Naval Review 1991, 90; Michael A. Palmer, "The Navy did its job." *U.S. Naval Institute Proceedings*, Naval Review 1991, 88.

[38] Naval gunfire was critical to the success of the Falklands Islands recapture. The British had 18 naval guns that fired 7,900 rounds in support of ground troops. Beirut is addressed in Chapter 5 and Appendix G. The actions in the Falklands were a major reason for the reactivation of the battleships in the 1980's. See John F. Lehman, Jr. *Command of the Seas*, (Annapolis, MD: Bluejacket Books, Naval Institute Press, 1988), 282-283, 327.

as it occurred just 16 years ago and is considered "the first major enterprise in jointness."[39]

In 1991, immediately following the war, Vice Admiral Stanley Arthur, Naval Forces Commander in the Persian Gulf War, commented favorably on the performance of naval gunfire during the Persian Gulf War. He stated, "16-inch gunfire contributed mightily to the amphibious deception…the power of 16-inch gunfire was demonstrated when a bombardment caused the Iraqis to abandon the coastal port of Ras Al Qualayah. Naval gunfire contributed greatly to the intensity and continuity of attack."[40] The only weapons capable of providing naval fire support were 16-inch guns as the Iraqi mine threat and shallow water prevented 5-inch gun ships from sailing close enough to shore to use their short range guns.[41] Reporting to Congress, the Department of Defense identified the considerable contributions of 16-inch gunfire. These fires gave credibility to the amphibious feint, breeched Iraqi defenses, destroyed Iraqi artillery and hard targets, and supported the ground offensive.[42]

The report *Conduct of the Persian Gulf War* noted as an issue the decommissioning of these ships after hostilities left a significant shortfall in naval fire support for which the Navy acknowledged it had no solution.[43] Admiral Arthur stated even though the battleships performed in an outstanding manner, his praise was "not a

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[39] Bernard Trainor, "Jointness, Service Culture and the Gulf War". *Joint Forces Quarterly,* Winter 1993-94, 71-74.

[40] Vice Admiral Stanley Arthur, "Desert Storm at Sea." *U.S. Naval Institute Proceedings*, Naval Review 1991, 82.

[41] *Conduct of the Persian Gulf War,* 259.

[42] Ibid., 273-274, 293, and 869-870.

[43] Ibid.; 870. Government Accountability Office. The Navy's comments to the GAO report cited the unique and important capabilities the battleships brought to the fleet. The response stated "troops landing on the beachheads are still subject to the threat against which the 16-inch gun is the most capable…the 16-inch gun provides the only naval surface fire support capability in support of over-the-horizon concept. With no replacement naval surface fire support system identified or programmed, the current 16-inch improvement program offers the most expeditious as well as practical, interim solution to the naval surface fire support range requirement in support of over the horizon operations." This improvement program was for the EX-148 13-inch sabot discussed in Chapter 5 of this study. See *BATTLESHIPS: Issues Arising from the Explosion Aboard the U.S.S. Iowa.* (Washington, DC: GPO, 29 January 1991), 13, 14.

plea to save the battleships."[44] He stated the high cost to operate and maintain the battleships was the primary reason for their decommissioning. However, no replacement for the battleships' capabilities was planned at the time of this statement.

Since that time, various congressional actions including statutory provisions to retain battleships in reserve, Government Accountability Office (GAO) studies, and specific authorization requirements for NSFS systems, have been undertaken to address the perceived NSFS shortfall.[45] The response from the Department of Navy has been to start (and in most cases subsequently restructure or terminate) various ship and fire support weapons programs. Examples of systems that were either canceled or significantly restructured include the Arsenal Ship, DDG-1000, Vertical Gun System, Extended Range Munition, Land Attack Standard Missile, and Advanced Gun System.[46] Not one of these proposed solutions have entered active service at the time of this writing. NSFS capabilities have not significantly improved since 1992, when the last battleships were removed from active service.[47] In 2001 the Marine Corps identified four

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[44] Arthur, 82.

[45] There are seven separate Government Accountability Office reports related to NSFS and battleships listed in the bibliography of this study.

[46] The GAO reports a clear vision of the changes in the NSFS programs and how they have not led to the fielding of a single system other than a slightly larger 5-inch gun. The DDG-1000 program started with the SC-21 program in 1994, which was restructured into the DD-21 program in 1997, which was restructured to the DD(X) program in 2001, which was renamed DDG-1000 in 2006. During this time the ordnance carried was reduced from 1,200 projectiles and 128 missile cells to 600 projectiles and 80 missile cells. See *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 14, 19-20; In 1999 the GAO told the Navy that it planned on developing and fielding the Land Attack Standard Missile (LASM); U.S. Government Accountability Office. See U.S. Government Accountability Office. *DEFENSE ACQUISITIONS: Evaluation of the Navy's 1999 Naval Surface Fire Support Assessment* (Washington, DC: GPO, 14 September 1999), 2; While promised as a solution in 1999, the Navy subsequently cancelled the LASM program during FY03 budget development. See *Information on Options for Naval Surface Fire Support*. (Washington, DC: GPO, 19 November 2004), 24. The Arsenal Ship gained attention in 1996 and by 2000 had quietly disappeared. See http://www.nps.navy.mil/tsse/files/1996.htm, http://www.fas.org/man/dod-101/sys/ship/arsenal_ship.htm and http://akss.dau.mil/docs/001EB001DOC.doc for additional information on Arsenal Ship concept.

[47] Sandra I. Erwin, "Navy Artillery: No New Weapons on the Horizon." *National Defense*; Mar 2006; 23.

naval surface fire support gun system projectiles that would soon enter the fleet. Six years later, not one had been fielded or operationally tested.[48]

Since the 1991 peak of the Reagan Administration's 600 ship Navy buildup overall surface combat ship numbers have been shrinking. Spruance Class destroyers are no longer in the active fleet.[49] No surface warship in the fleet today mounts guns larger than 5-inches. The Ticonderoga class guided missile cruisers are the only class of ships with more than one 5-inch gun. As capabilities for naval surface fire support provided from guns have dwindled, efforts to provide replacements for retired systems have resulted in just one new gun entering the fleet since 1992. That weapon, the Extended Range Munition (ERM) capable 5-inch/62 caliber gun, provides very limited increase in capability over the existing 5-inch/54 caliber gun currently fitted on most destroyers and cruisers.[50] Of additional concern are repeated test failures of the Extended Range Munition (five out of seven in 2005).[51] Recent articles lament the lack of movement on improving naval gunfire support, which is a major component of Naval Surface Fire Support.[52]

Marine Leadership voices concerns over lack of naval fire support: Senior leaders of the Marine Corps have discussed in open press their concern with the shortfall of naval fire support. General James Jones, as Commandant of the Marine Corps stated:

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[48] U.S. Marine Corps, *Marine Corps Warfighting Publication (MCWP) 3-16, Fire Support Coordination in the Ground Combat Element*. (Washington, DC: United States Marine Corps, 28 November 2001), 3-16.

[49] The Naval Vessel Register, accessed on 19 February 2007 at www.nvr.navy.mil, provides a listing and status of all ships that have been active in the U.S. Navy since the late 1700's.

[50] U.S. Department of the Navy. *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*. (Washington, DC: GPO, 21 January 2003), B-15. All new construction Arleigh Burke class destroyers from DDG-81 forward will receive the new 5-inch/62 caliber gun. Caliber indicates the length of a gun tube by multiplying caliber by the diameter of the bore.

[51] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 14; Also see U.S. Department of Defense Inspector General. *Acquisition: Audit of the Extended Range Guided Munition Program (D-2005-078)* (Washington, D.C.: GPO, 15 June 2005), 2.

[52] Hammond, "NSFS Shortfalls"; Erwin, "Navy Artillery." Most of this article addresses technical shortcomings of the Extended Range Munition for the 5-inch gun, the underlying theme is the Navy will not field any new fire support systems in the foreseeable future.

> "I have a lot of concerns about naval surface fire support…the Marine Corps should be concerned about fire support from the sea…what has taken up the slack for us is Aviation…but we still haven't solved the problem of how to see through the clouds in the close air support business or to deliver ordnance in all kinds of weather. Naval Gunfire…help(s) you get through that."[53]

Lieutenant General Emil R. Bedard (Deputy Commandant for Programs) stated "we have a hard requirement for a gun. We are not going to fall off that requirement."[54] This is significant given the clear movement away from gun based fire support to aircraft based fire support.[55] General Jones continued to express concerns by stating a year later (2001) when he said:

> "I know of no combat shortfall that's more important in my book, for the Marine Corps, than bridging the gap between the absence of naval gunfire and our own organic fire-support systems."[56]

Since 2000, two separate Marine Corps Commandants have testified to the Senate Armed Services Committee on the risk to Marines due to the lack of credible NSFS.[57]

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[53] Jason Sherman, "Keeping up with Jones," *Armed Forces Journal International*, June 2000, 14. General Jones additionally stated "… I regret we took them [battleships] out of service before we had actually fixed the naval surface fire support problem."

[54] Erwin, "Marines Clamor for Long-Range Artillery at Sea."

[55] "Naval surface fire support may be a requirement for successful prosecution of an amphibious assault…missions normally conducted by NSFS will initially rest with aviation assets." See U.S. Joint Chiefs of Staff, *Joint Publication 3-02; Amphibious Operations* (Washington: Joint Chiefs of Staff, 19 Sept 2001), XIV-8; "Air interdiction, naval surface fire support (NSFS), SOF missions, and/or other actions to prepare assault objectives will normally occur prior to the commitment of assault forces." However, NSFS shifts to "joint fires" with the following statement: "Throughout the assault phase, landed forces must have immediately available joint fire support to destroy, interdict, or suppress enemy forces." Fires are still required, but the source of the fires becomes vague or is specifically assigned to air assets. See U.S. Joint Chiefs of Staff. *Joint Publication 3-18; Joint Doctrine for Forcible Entry Operations* (Washington: Joint Chiefs of Staff, 16 July 2001),III-3.

[56] "Leading the Corps into the Future: An interview with General James L. Jones," *Armed Forces Journal International* (September 2001), 58.

[57] General James L. Jones testified on March 1, 2000, "We have been at considerable risk in naval surface fire support since the retirement of the Iowa-class battleships." See *Statement Of General James L. Jones Commandant Of The Marine Corps, United States Marine Corps, Before The Senate Armed Services Committee On March 1, 2000 Concerning Posture*, 17, accessed 1 April 2007 at http://armed-services.senate.gov/statemnt/2000/000301gj.pdf; General Michael W. Hagee state on Apri l 1, 2003, "Our Nation's expeditionary forces ashore will remain at considerable risk for want of suitable sea-based fire support until DD(X) joins the fleet in significant numbers." While he states the USMC supports the 5-inch ERM munition, the risk issue is still apparent. See *Statement Of General Michael W. Hagee Commandant Of The Marine Corps, United States Marine Corps, Before The Seapower Subcommittee Of The Senate Armed Services Committee, On April 1, 2003, Concerning Marine Corps Development And Procurement Priorities*, 22, accessed 1 April 2007 at http://armed-services.senate.gov/statemnt/2003/April/Hagee.pdf.

As recently as November 2004, the Marine Corps leadership formally expressed support for reactivation of the *Iowa* class battleships.[58] The Marine Corps changed its position in 2005 to support the Navy's efforts to remove the ships from the Naval Vessel Register, indicating they "support the Navy's modernization efforts to deliver a sufficient NSFS capability that exceeds that of the *Iowa* class battleships."[59] The analysis behind this change is addressed later in this study. Additional material related to battleships, including Navy opposition, is contained in Appendix G of this study.

Instead of retaining the battleships, the Marine Corps has identified a need for 24 DDG-1000 ships to meet the NSFS requirement.[60] The Navy only plans to build 7 ships.[61] Over the past 10 years, the Navy has consistently reduced the capabilities that it originally stated it would provide the Marine Corps in both the DDG-1000 and the Extended Range Munition (ERM) for the 5-inch gun.[62] The ERM was originally to be fielded in 2001, and is now expected to be fielded in 2011.[63] The first DDG-1000 was expected in 2008, and is now scheduled for 2014.[64] There are serious concerns with the stability and safety of the new tumblehome hull design of the DDG-1000, which in this

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[58] The Marine Corps specifically states the following: "Marine Corps supports the strategic purpose of reactivating two battleships in accordance with the National Defense Authorization Act of 1996 and supports the Navy's modernization efforts to deliver a sufficient NSFS capability that exceeds that of the *Iowa* class battleships." The fact that nothing of substance has entered the fleet to equal the firepower of the battleships since 1992 to the present date are likely reasons for the Marine Corps position in November 2004. The analysis supporting the Marine Corps change in position is not apparent to the author of this study. See GAO. *Information on Options for Naval Surface Fire Support*, 21; LtCol Estes worked fire support issues for senior Marine Corps leaders. He states Marine leaders were concerned with the fact that the battleships were not given all the capabilities required to meet Marine Corps requirements and that plans to improve their capabilities were cancelled before implementation. See Kenneth W. Estes, LtCol, USMC(ret). "Letters," *Marine Corps Gazette*, March 2006, 6.

[59] U.S. Government Accountability Office, *Issues Related to Navy Battleships, GAO-06-279R.* (Washington, DC: GPO, 13 December 2005), 5, 15. The report states that the Marine Corps, as stated by the Marine Requirements Oversight Council (MROC), "Supports Navy efforts to de-list battleships because battleships will not meet long-term Joint Fires capability requirements." This report further states "…DOD officials from joint staff, combatant commands, Navy, and Marine Corps do not believe that reactivating battleships would be cost effective nor would the modernized battleships significantly reduce those risks or provide the best means to meet long-term joint fires capability requirements."

[60] Ibid., 15.

[61] Ibid., 15.

[62] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 29.

[63] Ibid., 1.

[64] Ibid., 1.

configuration, has never put to sea.[65] Additionally, a number of ship building engineers question the ship's survivability if it is damaged under water.[66]

The Navy opposes battleship retention and reactivation.[67] Current Combatant Command (COCOM) representatives told Government Accountability Office (GAO) that existing war plans can be executed at acceptable risk using current forces with current fire support capabilities, primarily aviation.[68] This is expected as the services tell the COCOMs what forces they will receive.[69] COCOM staffs develop war plans using the forces currently available or available in the near future as identified by the service component commanders and in the Joint Strategic Planning Guidance.[70]

Current Marine Corps Concerns: During April 2006, General Hagee's (Commandant of the Marine Corps) cover letter to the Secretary of the Navy for a congressionally required report on NSFS stated, "operational lessons from Iraq and Afghanistan emphasize the value of volume and precision fires. The same can be said for detecting enemy indirect fire weapons." Hagee's cover letter was not provided to Congress. The Commandant's enclosure was included in the report, making two major points on the insufficiency of current capabilities: 1) current 5-inch guns are inadequate and existing munitions will soon be exhausted; and 2) Tactical Tomahawk (TACTOM) does not and will not meet tactical requirements.[71] Long range volume fires were

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[65] Christopher P. Cavas, "Is the New U.S. Destroyer Unstable?" *Defensenews.com*, 2 April 2007, accessed 3 April 2007 at http://www.defensenews.com/story.php?F=2666991&C=america.

[66] Ibid.

[67] *Issues Related to Navy Battleships*, 15.

[68] "DOD officials believe the level of risk associated with current fire support capabilities is acceptable given that other joint capabilities such as tactical aviation and long-range bombers could also contribute to providing joint fires to support theater commanders' war plans…However, Marine Corps officials support purchasing a larger number of DD(X) ships than are included in current Navy plans." See *Issues Related to Navy Battleship*, 5.

[69] U.S. Joint Chiefs of Staff, *Joint Publication 5-0; Joint Operation Planning* (Washington: Joint Chiefs of Staff, 26 December 2006), I-4.

[70] Ibid, I-4.

[71] *Report on Naval Surface Fire Support.* This report contains two appendixes, one from the Chief of Naval Operations views, and another from the Commandant of the Marine Corps. Further readings of

emphasized in at least four separate instances.[72] The report identified the lack of funding applied to a longer-range 5-inch conventional projectile that can increase existing ranges by 56% from 13 nautical miles to 21 nautical miles.[73] Two supporting capabilities, counter-fire radar and fire control command and control systems were also identified as major shortfalls.[74]

Summary: Joint and service doctrine calls for the ability to execute littoral forced entry operations. NSFS has been a critical battlefield enabler for many past amphibious forced entry actions and general littoral operations. Yet current capabilities are significantly reduced from those of the past and proposed capabilities are not yet in the fleet and their capabilities since originally proposed have been steadily reduced. A near-peer competitor is considered to require greater capabilities to overcome than the U.S. now possess. NSFS required to support other major littoral operations is not available. The Navy is not on track to provide robust NSFS in time to address the near-peer competitor as envisioned post 2015. Marine Corps leadership expressed concern over the lack of NSFS capability and until 2005, advocated retention of the two battleships in the reserve fleet. It is not analytically apparent why the Marine Corps changed its position. The Navy feels the risks are acceptable for not meeting the NSFS gaps.[75] The appearance of a near-peer competitor or a regional competitor with robust anti-access and anti-air capabilities is the critical issue related to the acceptability of current NSFS gaps. The near-peer and regional competitors and Marine Corps desire for volume fires are risk evaluation criteria in Chapter 8 of this study.

General Hagee's enclosure further outline his requirements, and show that many significant parts of the Navy's future program are under funded or completely unfunded. Additional shortfalls in support of NSFS such as counter-battery radar are also identified. One of the recommendations is that AEGIS ship's radars be modified to have counter battery detection and tracking capability.

[72] Ibid., USMC Enclosure, 2-5.

[73] Ibid., USMC Enclosure, 3.

[74] Ibid., USMC Enclosure, 4-5.

[75] GAO, *Issues Related to Navy Battleships*, 15.

Chapter 2: NSFS Studies and Reports

A number of reports and studies relating to NSFS provide either a historic view to past littoral forced entry operations or to the future requirements for NSFS. This chapter reviews the most significant of those reports available to the author.

Early Studies: Two available studies on naval fire support prior to the 1990s were reviewed for his study. The first was a 1953 Navy report on Naval Gunfire Support in Korea.[76] The report states that over 414,000 naval shells were fired supporting 24,000 fire missions between May 1951 and March 1952. This was an average of fifty seven missions per day and 17.25 projectiles per mission with approximately ninety percent fired by 5-inch guns.[77] The volume of munitions expended indicates significant support was provided to ground forces.

In the second report from 1977, Major General Donald M. Weller (USMC, ret) focused on historic execution of NSFS.[78] The report addressed three major topics: range, lethality and accuracy. The analysis of range is fairly straightforward. In the review of all three conflicts discussed by Weller, the report finds that most 16-inch (major caliber) missions were fired to ranges that exceeded those of the 8-inch guns (29,000 meters). About 25% of the 8-inch missions were fired at ranges greater than the 5-inch/54 caliber

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[76] U.S. Department of the Navy, *OEG Study 506: Characteristics of Naval Gunfire Support in Korea* (Washington, DC: Office of the Chief of Naval Operations, 11 June 1953), hereafter cited as "Navy, *OEG Study 506*."

[77] Ibid., 1-2. Additionally, in relation to the observations above, the report stated "Over 2/3 of the 16-inch destructive fire missions were claimed by observers to be highly successful. Over 1/2 of the 8-inch gun destructive fire missions when observed were claimed highly successful, and about 1/3 of the 5-inch missions were so regarded…it appears that either too much credit for effectiveness was given the lighter projectiles by observers, or too little given the larger projectiles…all batteries and particularly the heavy batteries appear to be credited with unreasonably accurate shooting at longer ranges and against small targets." Apparently the effectiveness of the observers was questioned.

[78] Weller, *Naval Gunfire Support of Amphibious Operations: Past, Present, and Future.* While a significant work, this study did not address "fires" as understood in 2007 as including air assets, rockets and missiles. This document does provide a good overview of naval gunfire support and associated aspects from WWII and Korea in detail, and Vietnam in generalities. The weapons analyzed were 5-inch, 8-inch and a single group constituting major caliber weapons such as 12-inch, 14-inch and 16-inch guns.

gun (23,000 meters).[79] This is in keeping with the 1991 Persian Gulf War where the average range of all missions fired by the USS *Wisconsin* and USS *Missouri* was twenty-two miles (35,398 meters).[80] The need for longer-range fires is a consistent issue for both naval and field artillery, and was again demonstrated during Operation Iraqi Freedom. For the field artillery, longer range was a must – especially since the Iraqi guns outranged those of the U.S. forces, as well as most coalition forces.[81]

The Weller report's lethality analysis mostly discusses types of targets and which guns were most effective against those targets. Significantly, all the major conflicts assessed (Central Pacific and Normandy in World War II, Korea, and Vietnam) had hard targets in significant numbers. Most significant is the assertion that 5-inch guns are ineffective against bunkers, bridges, airfields, underground personnel shelters, fighting positions, and tunnels. Their penetrative power is limited to two to three feet of reinforced concrete at best, and the density and weight of fragments is only effective against soft area targets.[82]

There are times, however, when 5-inch projectiles proved to be effective in suppressing and neutralizing soft area targets such as dismounted infantry, towed artillery, missiles and mortars without cover. Historically, 5-inch provided the vast majority of suppression fires during beach landings.[83] In these roles, 5-inch guns have

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[79] Weller, 4.

[80] *Conduct of the Persian Gulf War*, 262.

[81] MG Robert Scales, "Artillery's Failings in the Iraq War: United States must focus on range and precision," *Armed Forces Journal*, (November 2003), 44.

[82] A full overview of lethality is addressed in the Weller report. Additionally for 5-inch guns, the study stated against tanks, 5-inch guns are effective primarily for stripping dismounted or truck mounted infantry and engineers from the tank formations. Projectile lethality of the 5-inch gun against tanks was very low. Against dug in costal artillery positions (Korean War), destroyers were decidedly ineffective unless they could get a direct hit on the opposing artillery piece. See Weller, 5-6; Concrete penetration of 5-inch 54-pound armor piercing projectiles varies between 1 to 2 feet at maximum range of 18k yards. Concrete penetration of 16-inch 2,700-pound projectiles averages 15 to 20 feet at maximum range of 42,000 yards. See U.S. Department of the Navy, *Ordnance Pamphlet 1172: Performance of Bombs and Projectiles Against Shore Installations* (Washington, DC: GPO, 9 May 1944), 15, 16, 26.

[83] Weller, 5-6.

proven to be more than adequate. These suppression fires are often known as "volume fires" and require significant magazine capacity on board the mounting ship.

The larger caliber guns such as 8-inch and 16-inch proved capable of taking on all manner of hard targets such as bunkers and fortifications. The major caliber 16-inch gun was an especially effective killer of hard targets.[84] Significantly, Weller's report states hard targets were a problem in the past.[85] They continue to be a problem. Most recently, the Israeli Army's combat operations in Lebanon encountered large numbers of tunnels and underground fortifications. Because of the number of targets, the only way to destroy them was by hand (combat engineers or direct fire), a potentially costly approach in men and material.[86] There are further hard target requirements on the Korean Peninsula where over five hundred long range hardened and mobile artillery systems

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[84] Weller, 6.

[85] The general conclusions are hard point targets were primarily engaged and destroyed by heavy naval guns. 5-inch guns were generally ineffective against hard targets during WWII, Korean and Vietnam. At Iwo Jima, General Kuribayashi reported to Tokyo "However firm and stout pillboxes you may build at the beach, they will be destroyed by bombardment of main armament of the battleships. Power of American warships and aircraft makes every landing operation possible to whatever beachhead they like." By the end of the operation, 9,500 rounds of 12-inch, 14-inch and 16-inch ammunition, 20,000 rounds of 6-inch and 8-inch , and 182,000 rounds of 5-inch were fired. At Normandy, many guns were installed in heavy concrete emplacements. While high explosive rounds did not normally destroy them, they often induced the personnel inside to surrender. During the Korean War, dug in artillery positions were essentially immune to anything but 16-inch and 8-inch guns. Several large complexes were silenced by the fire of the larger naval guns. See Weller, 5, 98, 101, 110, 122-125, 156-160; For relative effectiveness, the 5-inch gun is rated with a base factor of "1". Against gun emplacements the 16-inch gun is given an effectiveness factor of "20", and against troops dug in it is given an effectiveness factor of "9.1." See *OEG Study 506*, 32; At Kawajalein Atoll and the assaulting force against on Roi-Namur encountered 17 pillboxes, and four reinforced concrete blockhouses. Naval guns destroyed almost all of these hard targets. At Iwo Jima there were 730 major defense installations, 21 block houses, 91 pill boxes, 32 covered artillery emplacements, half of which were knocked out by naval gunfire on the first day. At Normandy's Omaha Beach, there were over 35 pill boxes, eight concrete casemates, 60 light artillery pieces. Most were knocked out by naval gunfire. "By 1944…we had learned the importance of proper preparation of the objective by destructive fire, we had learned the essentials of beach neutralization, both in terms of weight of metal and in terms of timing; and we had come to realize…(naval) gunfire support is a vital part of the firepower of the Marine Division. See U.S. Marine Corps, *SM-67: Naval Gunfire in Amphibious Operations (NAVMC-7426)* (Quantico, VA: U.S. Marine Corps Education Center, April 1955), 6, 7, 13, 15, 20.

[86] Mark Dodd, "Iranian hand seen in tunnel network," *The Australian*, July 26, 2006, Sec. World; Eric Silver, "Death toll hits 23 as Israel hunts down Gaza rockets," *The Independent (London)*, October 16, 2006, Sec World,20; Anshel Pfeffer, "'Weasel' unit snuffs out terror tunnels," *The Jerusalem Post*, October 20, 2006, Sec News, 1; Each of these articles outline the large number of tunnels the Israeli Army encountered during their combat in Lebanon. The inability to take these out with artillery or other hard target systems requires combat engineers to remove them – at greater risk to the soldier.

oppose South Korea.[87] The presence of a major caliber gun system firing precision guided projectiles could change that dimension in a positive direction at some point in the future.

Analysis of ballistic accuracy is largely overcome by new capabilities for precision guidance of gun-launched projectiles.[88] The gun only needs to get the projectile in the general vicinity. Precision guidance capabilities will take it directly to the target. Several different methods such as Global Positioning System (GPS), inertial or laser guidance can greatly increase the accuracy of naval gun munitions.[89] However, it is worth noting that major caliber guns have been successfully used to fire as close as 300 yards to friendly troops.[90]

Studies in the 1990's: The Center for Naval Analysis (CNA) *1994 NSFS Cost and Operational Effectiveness Analysis (COEA) Final Report* was cited in 2006 as establishing the NSFS analysis baseline.[91] Key points of the COEA follow, with more detailed information contained in Appendix A. This COEA was the only time major and larger medium caliber guns (16-inch and 10-inch) have been evaluated since 1992. Portions of this report and its related documents are classified Secret. However, most of the relevant material for cost and effectiveness analysis and the conclusions are

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[87] Audrey McAvoy, "North Korean Missiles, Nukes boost U.S. Air Power deterrent role," *The Associated Press*, 4 December 2006.

[88] There are a number of new approaches to precision guided cannon artillery munitions that have been proven in live fire testing. The most notable is the Army's Excalibur 155mm precision guided munitions program. See https://picac2cs9.pica.army.mil/pmcas/News.aspx , http://www.raytheon.com/products/excalibur/ and http://www.dtic.mil/ndia/cannon/hansen.pdf. Also see Ron Laurenzo, "U.S. Navy faces fire support gap for the Marines," *Aviation Week & Space Technology*, 27 March 2006; Everett Tackett, "Successful Testing of GPS-Guided Artillery Projectile Puts Raytheon-BAE Systems Bofors Excalibur Closer to Fielding," *PR Newswire U.S.*, 18 August 2006.

[89] One program that addresses precision guidance for artillery projectiles is the Precision Guidance Kit managed by Picatinny Arsenal. Cursory information from the program manager was accessed on 20 December 2006 at https://picac2cs9.pica.army.mil/AdvancedSystems/ProductInformation/PgkPrecisionGuidanceKit.aspx.

[90] See Reilly, 184.

[91] U.S. Department of the Navy. *Capability Development Document (CDD) for the Extended Range Munition (ERM)* (Washington, DC: Department of the Navy, 22 May 2006), I; *Report to Congress on Naval Surface Fire Support*, 2. These two very recent documents are most significant as they identify the COEA as a baseline document to frame the analysis of NSFS requirements.

unclassified. These CNA documents were cited in a paper produced at the Marine Corps Staff College in 1997.[92]

The eight options recommended in the COEA varied in priority from a new 155mm/60 caliber gun to a new 8-inch/55 caliber light weight gun. All options were in combination with land attack missiles. The recommendations did not include a 5-inch gun.[93] This was noted as a significant issue by the Government Accountability office.[94] One of the two Navy long-range gun programs is a 5-inch gun projectile, which has suffered many technical problems and exceeded estimated cost by 550%.[95] The GAO was not provided access to the CNA COEA, likely due to these conflicting points.[96] In relation to larger caliber guns, the COEA also found the following:

> As the gun bore size and barrel length increase, the percentage of targets hit increases and the wartime cost per target decreases. This is due to the corresponding increasing maximum ranges and the increasing warhead weights of the rounds.[97]

The finding that large caliber guns are more cost effective in wartime is significant, yet because peacetime cost analysis was priority in the COEA, this finding was not emphasized.

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[92] *"Naval Surface Fire Support: Not Just a Substitute for Naval Gunfire!"* Marine Corps Staff College, Quantico, VA, 1997.

[93] The eight recommendations include a new 155mm gun, the same gun coupled with one of four different guided missiles, and three separate types of 8-inch guns. One of the reasons that a 5-inch gun was not in the recommended list was the lack of lethality to address a significant portion of the target set. Near-term budget constraints, as opposed to effectiveness, were cited as a reason for this option to become attractive. See Center for Naval Analysis, *NSFS COEA Final Report; CNR 210* (Arlington, VA: Center for Naval Analysis, October 1994), 4-5. Hereafter cited as "CNA, *NSFS COEA*"; GAO noted in their report that the 5-inch gun was not a recommended solution. See Government Accountability Office, *NAVAL SURFACE FIRE SUPPORT: Navy's Near-Term Plan Is Not Based on Sufficient Analysis* (Washington, DC: GPO, May 1995), 2, 3.

[94] *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 2-4.

[95] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 12, 14.

[96] *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 3. The GAO was not provided the final COEA report, they did get the list of recommendations.

[97] CNA, *NSFS COEA*, 89. Of the two recommended guns, the 155mm and the 8-inch (203mm) guns, only the 8-inch guns had the ability to achieve the required range of 165.5 kilometers (102 statute miles). And not one of the guns could kill 95% of the targets due to the inability to kill command and control bunkers at long ranges. This was due to the extremely small size of the 8-inch projectiles at maximum range. A 16-inch long-range projectile is significantly larger at the same ranges.

Other observations cited by the COEA were (1) guns beat missiles as low cost "sub-munitions trucks;" (2) none of the gun concepts considered can destroy certain hard point targets far enough inland [the targets and ranges are undefined]; and (3) a combination of guns [handling the majority of targets] and missiles defeated the target set at a minimum total life cycle cost.[98] One of the arguments against major caliber guns is that they cannot be mounted upon existing or programmed ship hulls as they are too small.[99] Existing 16-inch guns were screened out of consideration as they were assumed out of the fleet by 2003. Further, they were fully burdened with the annual operations and support (O&S) costs of the associated ships.[100] The report cited battleship O&S cost at $240 million, which does not match the Navy's database of record (see Chapter 7).[101] The COEA includes a hypothetical 10-inch gun in an Extended Range excursion; it concluded that "…for guns, cost per target always decreases with the increasing caliber…however this is only a wartime cost; larger guns have higher peacetime costs."[102] All analysis was conducted against a target set that included hard targets such as command and control bunkers and fighting bunkers.[103] The CNA COEA considered aircraft as part of the overall mission set but did not provide an associated cost analysis linked to NSFS.

Summary: Both the Operational Evaluation Group and MG Weller's studies identify three main points: 1) naval gunfire support was critical to past operations; 2)

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[98] CNA, *NSFS COEA*, 3-4.

[99] Interview, Robert Sullivan, Center For Naval Analysis, 7 November 2006. Major caliber guns were not considered (as full options), because the NSFS COEA tasking was to compare solutions appropriate for existing and planned ship classes.

[100] CNA, *NSFS COEA*, 11. 37 and 38.

[101] Ibid., 37; Interview, Robert Sullivan, 7 November 2006; The CNA COEA authors could neither determine the source within the Navy for the $240 million nor provide any specific details of its structure. Later in this study the actual O&S average of $83m per year is addressed.

[102] Ibid., 121. The excursion postulated a 10-inch gun design and determined that at range factor of 2 (twice the COEA ranges), the 10-inch gun and the most successful missile option (ATACMS ER) each satisfied the 95% of targets. It is also significant that at longer ranges the cost per target for the gun options increases steadily with range factor as more of the smaller, longer range shells are required to achieve the same results of the larger shells.

[103] Ibid., 60.

major caliber guns were key to long range support and destroying hard field fortifications; and 3) many small caliber (5-inch) rounds were fired in support of ground forces and were effective in suppressing the enemy. The CNA COEA concludes that a mix of guns (155mm and 8-inch) and missiles provide the most economical ability to engage the majority of NSFS targets at long ranges. The 5-inch gun's lack of lethality was the primary factor in CNA not including it in the recommendations. In wartime, the operational effectiveness and the high cost for missile replacement and large volumes of less effective smaller caliber projectiles makes the major caliber gun, which is operationally the most effective, and also the most economical. Lethality, volume fires, and cost effectiveness are risk evaluation criteria in this study's recommendations presented in Chapter 8.

Chapter 3: Marine Corps Requirements for NSFS (1996-2002)

The Marine Corps Combat Development Command (MCCDC) published requirements documents addressing Naval Surface Fire Support in 1996, 1999 and 2002. This chapter addresses the highlights of these documents, with greater detail provided in Appendix B.

The range baseline began with a 1995 agreement between the USMC and the Navy stating the initial range requirement threshold was 41 nautical miles and the objective was 63 nautical miles.[104] The 1996 requirements document reinforced the range benchmark and established requirements criteria for; 1) fire control interoperability; 2) target acquisition; and 3) weapons systems characteristics.[105] The range requirements remained unchanged.

The 1996 requirements document stated NSFS systems must "respond as closely as possible to the call for fire mission processing times specified for artillery."[106] This document also specifically stated that fires command and control systems must be interoperable. In 2006 the GAO noted this as a continuing shortfall that is not being addressed and requires a sponsor within the Navy to develop and field a solution.[107]

It is appropriate that NSFS response times be held to the same standards for self-propelled field artillery. While timeliness is not as important on pre-planned targets, fire support for maneuver forces or for unanticipated emergency hard or soft targets requires near-immediate response times. The 1996 document established a time of two minutes,

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[104] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 8.

[105] Commanding Officer, Marine Corps Combat Development Command, *Naval Surface Fire Support Requirements for Operational Maneuver from the Sea*. (Quantico, VA: U.S. Marine Corps Combat Development Command, 3 December 1996), Cover letter. Hereafter cited as "USMC, *MCCDC 1996 NSFS Requirements for OMFTS*."

[106] Ibid., Enclosure 1, 1

[107] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 4. There were four recommendations in this report, one of which was "the gap in command and control of joint fires for littoral operations be assigned to the appropriate organization and coordinated with the Navy's work on engagement gaps." This shortfall ties directly to the 1996 requirement for interoperability identified in this and subsequent USMC requirements documents and statements.

thirty seconds from call for fire to rounds on target.[108] This is eight seconds longer than the Emergency Fire Mission (a mission received when the artillery piece is moving) standard for the Army's PALADIN self propelled howitzer of seventy five seconds till first round fired, to which is added an additional one minute, twenty three seconds, for maximum time of flight to impact of the shell on the target.[109] The 1999 document changed the timeliness requirement from two minutes thirty seconds from call for fire to rounds impacting the target to two minutes thirty seconds from call for fire to *firing* the first round.[110] Unlike the previous document, time of flight of the ordnance is specifically discussed with the statement "any technology that can reduce time of flight should be pursued….even as little as 2.5 minutes can be the difference between life and death."[111] While the 2002 document maintains the revised standard mission response time of two minute thirty seconds till launch of ordnance, it added the following:

> Several studies have indicated that a total mission time (call for fire to rounds on target) greater than ten minutes significantly increases the probability of missing a relocatable target. Minimizing time of flight, as well as the total mission processing time is of vital importance when providing close supporting fires to maneuver forces in contact with the enemy. Any technology that can reduce time of flight should be pursued.[112]

The ten-minute total response time was not a hard and fast requirement. This was an improvement over the 1999 standard which had no formal consideration of the timely

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[108] USMC, *MCCDC 1996 NSFS Requirements for OMFTS*, Enclosure 1, 5.

[109] Army, *Mission Training Plan Field Artillery, Consolidated Cannon Battery*, A-15. The 75 second requirement drops to 60 seconds if the howitzer is moving within its battery position – further reducing the time standard to 2 minutes 15 seconds.

[110] Commanding Officer, Marine Corps Combat Development Command, *Naval Surface Fire Support Requirements for Operational Maneuver from the Sea*. (Quantico, VA: U.S. Marine Corps Combat Development Command, 16 June 1999), Enclosure 1, 7-8. Hereafter cited as "USMC, *MCCDC 1999 NSFS Requirements for OMFTS*." The Marine Corps also indicated loitering munitions would likely meet the increased mission response time alluded to in the ten minute limit suggested in the document. The ten minute response time is not identified as a firm requirement in this document.

[111] Ibid., 8. This significantly alters the impact of the stated USMC requirement, in effect, makes it open ended and not bounded by impact of the ordnance. By this definition the Tomahawk missile is considered tactically timely when fired at maximum range and taking up to two hours to hit the target.

[112] Commanding Officer, Marine Corps Combat Development Command, *Naval Surface Fire Support Requirements for Expeditionary Warfare*. (Quantico, VA: U.S. Marine Corps Combat Development Command, 19 March 2002), Enclosure 1, 10-11. Hereafter cited as "USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*."

arrival of ordnance on target. For normal fire missions (non-emergency), the standard identified for Field Artillery cannon batteries varies between three minutes, forty-five seconds to just less than four minutes for a PALADIN battery depending upon the mission and munitions used.[113]

The accuracy requirement was consistent amongst all three documents, with the requirement being a 50-meter circular error probable (CEP) threshold and a 20-meter CEP objective (see note for CEP definition).[114] In addition to ordnance accuracy, the accuracy of the target location must also be considered. The Defense Science Board (DSB) determined actions anything done to reduce TLE will greatly improve precision accuracy. [115]The following chart from Field Manual 6-40, *Field Artillery Manual Cannon Gunnery* shows that various target sensors have high Target Location Error (TLE).

TLE = 0 Meters (CEP)	TLE = 75 Meters (CEP)	TLE = 250 Meters (CEP)
Forward observer with laser	Counterbattery Radar	Forward observer w/o laser
Target area base	Airborne infrared system	Air observer
Photointerpretation	Flash ranging	Tactical Air (w/o designator)
Airborne target location	Countermortar radar	Long-range patrol
		Side-looking airborne radar
		Communications intel

Table 1: Target Location Errors for various sensors[116]

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[113] *Mission Training Plan Field Artillery, Consolidated Cannon*, A-10 to A-13 and A-17 to A-43. This document provides the basic field artillery timeliness requirements, as well as the PALADIN standard for an emergency mission time of two minute thirty seconds. Time standards vary by several minutes depending upon the type of mission being fired and the weapon system executing the mission. There are twenty-three missions identified in the MTP, of which the two longest are the smoke, which requires six min fifty-five seconds to fire, and the field artillery scatterable mine mission which requires seventeen minutes and ten seconds. The processing time (observer to first round fired) varies from two minutes fifteen seconds for "Time on Target", to two minutes forty-five seconds for first round "fire for effect, large segmented target", to six minutes fifty-five seconds to "adjust smoke." Of the twenty-three enumerated missions, seventeen must achieve first round on target in less than three minutes. Only two require times greater than four minutes fifty seconds until first round impacts target. The towed artillery is only one to two minutes longer than PALADIN time lines except for emergency missions where the towed artillery is not emplaced. Those missions require a ten to twelve minute response depending upon the firing platform.

[114] Ibid., Enclosure 1, 18-19. Circular Error Probable CEP is "…the error in range, deflection, or in radius, which ordnance may be expected to exceed as often as not. In other words, it is the radius of a circle within which half of a number of projectiles fired or missiles launched are expected to fall." The document states "The threshold CEP is 50 meters at all ranges, which is similar to current artillery capabilities. Based on estimates of what technology will be able to provide, the objective CEP is 20 meters at all ranges."

[115] U.S. Department of Defense, *Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace* (Washington, DC: Department of Defense, October 2004), 16.

[116] U.S. Department of the Army, *FM 6-40/ CWP 3-1.6.19, Field Artillery Manual Cannon Gunnery*, (Washington, DC: GPO, 23 April 1996, including Change 1, 1 October 1999), Table C-6.

Large magazine requirements are somewhat reduced by new precision capabilities. This is true to the point that the projectiles are lethal enough to kill the target on the first hit, and there is zero TLE in the firing coordinates. However, TLE is not just a problem of seeing the target, it is also correctly locating the ground coordinates of the target. Ground elevation and accuracy of local survey (maps) can negatively affect TLE. Poor visibility also negatively impacts TLE. Large TLE increases the number of rounds required to achieve the desired effect on the target.[117] In situations were TLE is large, precision becomes *precisely wrong*.[118] A major advance the Precision Guidance Kit (also see page 46) provides is the ability to program artillery "sheaf" (multiple shell impact pattern) by ensuring all projectiles land in their assigned portion of the pattern. This reduces the number of rounds to cover an area target or to account for large TLE.[119]

Volume fires constituted a significant portion of the 2002 requirements document and include suppression and neutralization of enemy capabilities.[120] Volume fires were benchmarked initially upon the capacity of a field artillery battery. However, the number of rounds required depends upon multiple factors:

> Depending on the morale, training, etc. of the enemy force, the number of rounds required may either increase or decrease. Based on the actions/inactions of the enemy, only the supported commander can determine whether the fires have achieved the desired effects. Naval surface fires must be capable of substituting for any fire support asset cited in the above example.[121]

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[117] *Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace*, 19.

[118] Ibid.

[119] The FY2007 President's Budget includes funds to further develop the Precision Guidance Kit (PGK). The budget exhibit explaining the program was accessed on 20 December 2006 at http://www.js.pentagon.mil/descriptivesum/Y2007/Army/0604802A.pdf (page 21).

[120] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 1, 15-16. While no specific numbers of projectiles are provided to directly create a battlefield effect, rates of fire are identified are not far off from the volume of explosives required as identified by Vector Research and their Suppression Effects Study performed for the U.S. Army Human Engineering Laboratory. See David Thompson, Robert Robillard, Dennis Wylie, and Robert Mackie, eds. *Suppression Effects Study: Volume 1 – Main Report* (Aberdeen Proving Ground, MD; U.S. Army Human Engineering Laboratory, October 1990).

[121] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 1, 16. The fires that NSFS are identified as being able to substitute for are aircraft, both fixed and rotary wing, and field artillery of the ground force.

The ability to deliver volume fires and to remain on station for extended periods of time requires a ship with significant magazine capacity. Colonel William Darby, the leader of the first Ranger units in World War II, eloquently addresses volume fire capabilities of the USS *Savannah's* fifteen 6-inch guns as follows:[122]

> We were in a very desperate situation…we just couldn't move. They had a tremendous amount of small arms fire and they had a very well dug-in and well built position – concrete emplacements, pill boxes and all. I had this little lieutenant of Artillery with me, who had all the naval gunfire of the *Savannah* at his control, and I decided to put him to use. I had one of my men who was in position on top of the hill up here and who could see the gun batteries that were firing on us, some five 149 and 150 howitzer batteries that were blazing away. I never realized naval gunfire could be so accurate. We started firing with *Savannah* and before we finished... forced five batteries to stop shooting. We examined those gun positions and in every battery position we found at least one gun with a direct hit and at least one stack of ammunition blown in each place…
>
> Before I took Butera she was giving fire support to me – and accurate fire support – at a range of 22,000 yards, which I think is something for people to remember. Naval gunfire support with ground observation and good communications is just like anybody else's artillery: It is good. As a matter of fact, it is awfully fine artillery because when you say "fire for effect", you have 45 rounds of 6-inch shells in one minute. They have 15 guns and fire about three rounds a minute.[123]

The DDG-1000 is designed with two Advanced Gun System (AGS) 155mm rifles with a rate of fire of approximately ten rounds per minute. Though the guns are in essence the same size as the 6-inch (152mm) guns of the USS *Savannah*, the rate of fire is less than half, and the magazine capacity is 10% of an equivalent World War II vessel.[124] This matters against a capable opponent presenting a target rich environment.

Modern warships carry far fewer weapons and a fraction of the ammunition of their predecessors, limiting persistency on station and the ability to deliver volume fires when required. Precision not withstanding, experience and solid analytics supporting a 70% to 90% reduction in magazine capacity from WWII era ships has yet to surface. Again, this will be a problem in a target rich environment.

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[122] Colonel William C. Darby, "U.S. Rangers" (lecture at the Army and Navy Staff College, Washington D.C., on 27 October 1944), Joint Forces Staff College Library, Norfolk, Virginia. 21.
[123] Ibid., 25-26.
[124] U.S. Government Accountability Office, *Progress of the DD(X) Destroyer Program, GAO-05-752R* (Washington, DC: GPO, 14 June 2005), 12.

The following chart provides a comparison of current and past ship magazine load capacities. The Ticonderoga and Arleigh Burke ships are identified with the two main munitions for the 5-inch gun system. Both munitions are fired from the same gun.

					Missions per Ship		
Ship Class	**Gun**	**Mounts**	**Guns**	**Approx Rounds on Ship**	**8 rds per mission**	**22 rds per mission**	**40 rds per mission**
Iowa (BB) (1980's)	16-inch/50 Cal	3	9	1,200	150	55	30
	5-inch/38 Cal	6	12	7,000	875	318	175
Baltimore (CA)	8-inch/55 Cal	3	9	1,350	169	61	34
	5-inch/38 Cal	6	12	5,000	625	227	125
Cleveland (CL)	6-inch/47 Cal	4	12	3,000	375	136	75
	5-inch/38 Cal	6	12	6,000	750	273	150
Worchester (CL)	6-inch/47 Cal	4	12	5,100	638	232	128
Fletcher (DD)	5-inch/38 Cal	5	5	2,775	347	126	69
Summner (DD)	5-inch/38 Cal	3	6	2,100	263	95	53
Arleigh Burke (DDG)	5-inch/62 Cal	1	1	244	31	11	6
	5-inch/62 ERM			232	29	11	6
Ticonderoga (CG)	5-inch/54 Cal	2	2	780	98	35	20
	5-inch/54 ERM			534	67	24	13
DDG-1000	155mm AGS	2	2	600	75	27	15

Table 2: Number of missions per ship example (see footnote for detailed explanation)[125]

The chart above illustrates the significantly greater capacity of the older warships assuming all weapons are firing precision-guided munitions. The 5-inch munition's lack of lethality will keep rounds per mission above 20, and more likely in the 30-40 round per mission category. All ships with 5-inch guns as secondary armament carry approximately seven to eight times the rounds of DDG-1000, Ticonderoga CG or Burke

[125] "…the average fire mission requires 22 rounds of 155mm LRLAP to achieve desired effects. Therefore it is assumed that the sustained or surge firing rates will be divided into individual engagements each averaging 22 rounds." The document cites the rounds per ship (magazine capacity) for DDG-1000, DDG-51 and CG-47. See Navy, *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*, 8-6, 8-7; Ammunition loads provided for Fletcher and Sumner class destroyers. See Norman Friedman. *U.S. Destroyers: An Illustrated Design History* (Annapolis, MD: Naval Institute Press, Reprinted, 1982),190-191, 414-413; Ammunition loads for the *Iowa*, Baltimore, Cleveland and Worchester class ships was provided by Mark Wertheimer of the Naval Historic Center (5 and 21 February, 2007) based on Ship Ordnance Equipment Lists and an undated (estimate about 1950) draft copy of Naval Warfighting Instruction Publication 221, Naval Gunfire Support in Amphibious Operations; The CNA COEA's average rounds per mission for 8-inch and 16-inch guns were five to seven rounds. Average for 155mm LRLAP was about ten per mission, and 5-inch averaged between 24 to 43 rounds per mission. In the chart above, the eight rounds per mission estimate was the average between the 155mm average and the 8-inch/16-inch average. The 40 round average was a combination of field artillery unclassified training estimates and the 5-inch expenditures. See CNA, *NSFS COEA*, 90. Data declassified 8 February 2007 by OPNAV, N86. Declassification notification maintained by Joint Forces Staff College Ike Skelton Library.

DDG. Ships with 8-inch and 16-inch guns carry twice as many main battery rounds and far more 5-inch rounds than DDG-1000 carries of main gun. Having more than one gun per ship is a good, as demonstrated when Australian and Royal Navy ships providing naval fires in Operation Iraqi Freedom experienced gun failures.[126] Chapter 5 continues the discussion of volume fires.

The Navy estimates indicate that one fire mission is generated every 4.5 minutes in a forced entry scenario producing about 13.3 missions per hour.[127] At that rate and twenty-two rounds per mission, both the DDG-51 and the CG-47 are expended within one hour. The DDG-1000 is expended in two hours. Ships with larger munitions than LRLAP expend in eleven hours vice two hours assuming eight rounds per mission as opposed to twenty-two per mission due to their more lethal munitions. Magazine size matters when supporting troops in the close fight.

Of equal importance is logistics sustainability. If modern ships are likely to empty their magazines quicker, they will be on station for a shorter period of time requiring more ships to maintain presence and rate of fire.[128] This supports the initial Navy program of thirty-two DDG-1000 ships. Of more concern is the Navy's view that "Replenishment at Sea equals sustainment."[129] The ship must depart the firing area to replenish which does not support volume fires or sustained fires.

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[126] Ivan Ingram, "Naval Gunfire Support for the Assault of the Al Faw Peninsular," *Journal of the Australian Naval Institut*e, Number 109. (Winter 2003), 35, 36.

[127] Navy, *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015* (Washington, DC: Department of the Navy, 21 January 2003), 8-6, 8-7. Calculations based upon CONPS data indicate that during the sustained level of support the ground force will generate approximately one NSFS fire mission every 20 minutes. During the assault phase, one NSFS fire mission will be generated every four and a half minutes on average. These missions vary in types such as suppression, destruction, interdiction, neutralization, etc., such that on average each mission requires 22 rounds. Since the average fire mission is twenty-two rounds, then the average rate of fire at the sustained level is about one round every minute, whereas the high intensity (surge) scenario requires about five rounds per minute.

[128] Ibid., 8-3. VLS missiles cannot be replenished at sea. Gun munitions can replenish at sea. DDG-1000 takes an average of 13 hours including 50nm transit to replenish. Both CG-47 magazines require 24-32 hours to replenish. DDG-51 requires about 16 hours for 680 ballistic projectiles and propelling charges. In the past battleships and cruisers took one to two days to replenish at sea.

[129] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 1, 21.

Hard targets were identified in the 2002 document without specificity as to type.[130] The Army has specific expectations of naval gunfire to address hard targets such as bunkers and hardened positions as stated in FM 3-09.42, *HBCT Fires and Effects Operations*:

> Ammunition variety, combined with high rates of fire, high muzzle velocity, and precision fire control equipment make naval surface fires particularly suited for attacking targets that present a vertical face on the forward slopes of hills and for direct fire or assault fire, particularly against reinforced targets such as bunkers and hardened positions.[131]

After the third Marine Corps document was issued in 2002, the Marine Corps drafted an overarching NSFS requirements memorandum of agreement. However, the Navy refused to agree with this memorandum.[132]

Summary: The most significant change from the 1996 requirements document to the 2002 requirements document is loosening the time requirement of two minutes thirty seconds from call for fire to first round on target to a "system response" time to the launch of ordnance. The Emergency Fire Mission standard for the Army PALADIN self propelled howitzer should be the standard upon which NSFS systems supporting troops in contact with the enemy are judged. Target Location Error (TLE) can reduce effects of precision. Marines require volume fires, but current ships lack the required magazine capacity with DDG-1000 being 20% to 25% of historic destroyer capacity. Both the Army and Marines expect naval gunfire to kill hard tactical targets. Lethality (hard targets) and volume fires are risk evaluation criteria in Chapter 8.

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130 USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 2.
131 *Field Manual Interim 3-09.42: HBCT Fires and Effects Operations*, 163.
132 *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 8.

Chapter 4: The NSFS Initial Capabilities Document (ICD)

The joint requirements process directly reviewed NSFS for the first time beginning in 2004. The purpose of the analysis was to determine the capabilities gaps to execute "Joint Fires in support of Expeditionary Operations in the Littorals." Detailed information is available in Appendix C on this process known as the Joint Capabilities Integration and Development System (JCIDS). This chapter focuses on a few selected parts of that analysis which produced the Initial Capabilities Document (ICD) for "Joint Fires in support of Expeditionary Operations in the Littorals."

Identifying Capabilities Gaps: The primary purpose of the ICD capabilities-based assessment is to identify gaps in capabilities against known requirements. The analysis centered on current systems and programs of record that will be fielded by 2015. If shortfalls are still present in 2015 they are identified as significant gaps that require solutions.[133] It is a matter of record that the ground force has reduced organic fires capability and now depends heavily on "joint fires."[134] The ICD analytic framework design reinforced this through its focus on "the interoperability of fires, and increased the emphasis on effects and responsiveness of fires while de-emphasizing the service or component of origin, hence the transparency of fires."[135] This approach removes visibility of the specific system performance parameters and makes full analysis of system performance more difficult. Four gaps were identified as a result of the analysis:[136]

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[133] U.S. Department of the Navy. *Initial Capabilities Document (ICD) for Joint Fires in Support of Expeditionary Operations in the Littorals (Version 1.2)* (Washington, DC: Department of the Navy, 1 November 2005), 1. Hereafter cited as *ICD for Joint Fires in Support of Expeditionary Operations in the Littorals*.

[134] *Field Manual Interim 3-09.42: HBCT Fires and Effects Operations*, 8-1, "The HBCT has limited organic fire support assets and relies heavily on joint fires and reinforcing fires provided by a fires brigade when available."

[135] *ICD for Joint Fires in Support of Expeditionary Operations in the Littorals*, 6, 7.

[136] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, cover summary page.

Gap 1 - Ability to transmit and receive the required targeting information from intelligence, surveillance and reconnaissance and targeting (ISR&T) sources to fires command and control systems.
Gap 2 - Ability to engage moving point and moving area targets under restricted weather conditions.
Gap 3 - Ability to engage known and/or identified targets when friendly forces are in close contact or when collateral damage is a concern.
Gap 4 - Ability to provide fires to achieve volume effects (i.e. suppression).

Functional analysis: Two scenarios were modeled in "ideal" and "restricted" (weather and rules of engagement) conditions. One scenario was a major combat operation, and the other involved a non-major combat operation focused on the Global War on Terrorism (GWOT).[137] The ICD development oversight board composed of senior leaders from the JCS, the U.S. Navy, U.S. Army and USMC approved the scenarios.[138] The weapons considered in the analysis were grouped into three categories: (1) air, both fixed and rotary wing; (2) ground, both U.S. Army and USMC; and (3) NSFS. The NSFS systems were the 5-inch gun Extended Range Munition (ERM), the 155mm Advanced Gun System Long Range Land Attack Projectile (LRLAP) and the Tactical Tomahawk Missile.[139] This robust effort does indicate a need for additional fidelity and/or detailed analysis.

Several areas of interest emerge from the study. First, no Post Independent Analysis (PIA) was conducted by a competent disinterested party. During the development of this ICD, the JCIDS process required this type of analysis.[140] After this

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[137] Ibid., 5, 6, 29. The major combat operations scenario had three phases. Battle Space Preparation phase, assault/insertion phase, and a sustained operations phase In addition to three phases and three weapons groups, there was also an "ideal case" and a "restricted case" analysis applied to each phase. The restricted case applied restrictions for weather and rules of engagement related to collateral damage and missions on close proximity to friendly forces. The GWOT scenario was based upon special operations forces calling fires against terrorists..

[138] Brian Schiers, 14 December 2006.

[139] Marine Corps Combat Development Command and Whitney, Bradley and Brown, Inc. , *Joint Fires in Support of Expeditionary Operations in the Littorals: Initial Capabilities Document Functional Needs Analysis* (Quantico, VA: United States Marine Corps, 2005), Slide 6. Hereafter cited as "*Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA*."

[140] U.S. Joint Chiefs of Staff, *Chairman of the Joint Chiefs of Staff Instruction 3170.01E. Joint Capabilities Integration and Development System*. A-6. The instruction states "The result of the PIA will

ICD was approved, the JROC Memorandum 062-06 dated 17 April 2006 removed the PIA as a required step and made it an optional step for sponsor-developed capabilities based analysis in developing an ICD.

The second area of interest is the lack of definition of hard targets engaged such as fighting bunkers, reinforced field fortifications, command and control bunkers, and hardened/buried gun positions. This is not in consonance with the well-documented past and present use of these types of targets by past and potential opponents. In the past these targets were successfully engaged with major caliber guns. The majority of targets are considered in other analysis not related to littoral expeditionary operations.[141] There is also reason for concern with identified "quantity" gaps for fixed hard and medium targets. The FNA states there are not enough delivery platforms to service the targets and answer all the other calls for fire. However, no quantification of targets or platforms is provided for this quantity shortfall.[142] Lack of shortfall specificity in aircraft, naval gun, missile, or field artillery makes one of the JCIDS goals (balance service procurement programs) more difficult to achieve by clouding the capabilities and limitations of different systems.

A third area of interest is the inclusion of Tactical Tomahawk. The NSFS weapons systems cited in the study are 5-inch Extended Range Munition (ERM), the 155

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be to confirm the decision to develop an ICD, a joint DCR and/or a sponsor DOTMLPF and/or policy change to initiate the process to satisfy the capability needs."

[141] *Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA* , Slide 4; Mr. Brian Schiers, 14 December 2006. Fighting and command and control bunkers are included in a separate target set that is currently under consideration in the Hard and Deeply Buried Target Initial Capabilities Document (HDBT ICD) of which the Air Force is the sponsor and service lead.

[142] Ibid., Slide 11; The notes in the referenced slide state the following: "There are a number of hard and medium targets in the assessed target set representing aircraft shelters, C2 bunkers, runways etc. As mentioned in slide 3 above, there are specialized weapons in the 2005 and 2015 inventories that are capable of servicing these target classes but in this scenario there were not enough delivery platforms to service these plus the other calls for fires. Accordingly, this gap is considered to be a *quantity* gap as opposed to a *capability* gap. This apparent gap will persist throughout the iterations of phases and timeframes in this FNA." A precision gun based solution would attack these targets in a more cost and operationally effective manner if the magazine capacity and lethality were appropriate. A quantification of this shortfall would assist a good programmatic review.

mm Advanced Gun System (AGS) and the Tactical Tomahawk missile.[143] The Commandant of the Marine Corps specifically notified Congress in April 2006 that Tactical Tomahawk is not considered a tactical NSFS weapon, but rather an operational and strategic strike weapon.[144] The documentation did not have fidelity for the impact of guns vs. Tactical Tomahawk missile or aviation delivered ordnance. The study author was unable to provide a breakout of how many targets were addressed by the various weapons systems.[145] The TACTOMs high cost (up to $1.06 million) compared to other potential NSFS options further indicates this weapon is not a valid tool for tactical fire support.[146] Chapter 7 and Appendix E contain additional related cost analysis.

A fourth area of interest is compliance with the ten-minute standard of the call for fire to delivery of ordnance on target. The ICD states that ten minutes is the timeliness required from "fire request to effects on the target."[147] No data is provided in any of the ICD documents that addresses whether or not each system met the ten-minute response standard for call for fire.

A fifth area of interest is the Phase One (Preparation) ideal case and restricted (weather and rules of engagement) case. This phase was limited to air and NSFS assets.[148] Not one of the NSFS weapons were identified with the number and type of

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[143] Ibid., Slide 6.

[144] *Report to Congress on Naval Surface Fire Support*, Commandant of the Marine Corps Attachment, 3; Even under ideal conditions, Tomahawk can not meet the 10 minute requirement to answer a call for fire with ordnance on target. The specific statement in the Marine Corps section of the report states "The use of TACTOM for tactical level fire support is not feasible. While designed to be more flexible and responsive, relative to conventional Tomahawk missiles, the release authority and the cost of the TACTOM drive it to remaining a strike weapon suited for operational and strategic employment."

[145] Brian Schires, 14 December 2006.

[146] FY2007 OSD Program Weapons Cost Book, accessed 20 Nov 2006 at www.dod.mil/comptroller/defbudget/fy**2007**/fy**2007**_weabook.pdf. This cost includes research, development and tooling.

[147] *ICD for Joint Fires in Support of Expeditionary Operations in the Littorals*, 10-11. The return of the ten minute effects standard is an improvement over the previously unbounded requirement. However, it is about seven minutes and thirty seconds longer than the most stringent field artillery requirement as noted earlier in this document.

[148] Ibid., 11, Table 1; *Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA*, Slide 9-15.

targets successfully engaged in the analysis. Given small magazine capabilities of the proposed NSFS gun systems and low projectile lethality, the lack of a detailed weapon-to-target analysis makes it difficult to judge the system effectiveness. Phase Two (Forced Entry) included land force fires, but there was no target-to-firing system specificity.

A sixth area of interest is that Gap 2 and Gap 4 required response time is stated as twelve hours a day, seven days per week.[149] Fires should be available twenty-four hours a day, not twelve hours. The Defense Science Board identified in 2004 that all future indirect fires required a twenty-four hour seven day per week response time.[150] Gap 4 indicates a minimum range of thirteen miles, twenty-eight miles shorter than the Marine Corps threshold requirement of forty-one miles.[151]

Additional areas of interest are lack of analysis of magazine capacity, documentation of hypothetical enemy force structure and size, a description of which weapons engaged which targets and what the priorities for engagement were, discussion of the location of target acquisition assets (and their associated Target Location Errors) or information on any maneuver reactions by red forces against blue force actions. While these may have been addressed, available documentation is lacking for confirmation.

The chart on page A1 of the ICD shows a very heavy aviation and missile weapons set. In CNA's previous assessments, air delivered ordnance was shown not to be as responsive as gun based systems, and contains significant risk if weather, non-permissive air environment or more pressing missions pull aviation away from the ground tactical fight.[152]

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[149] *ICD for Joint Fires in Support of Expeditionary Operations in the Littorals*, 10-11.
[150] *Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace*, 10.
[151] Ibid., 11; USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 2.
[152] Center for Naval Analysis, Memorandum for Major General H. W. Jenkins (N85) and Mr. Ronald Kiss (DASN (Ships)), Co-Chairs, NSFS COEA. Subject: Naval Surface Fire Support (NSFS) COEA, 14 January 1994; This document reinforces material already published in the basic CNA COEA document.

Targeting and command and control Gap #1: As important as the weapon is the ability to get targeting data to the weapon in a timely manner. The capabilities Gap in transferring targeting data from Intelligence, Surveillance, Recognizance and Targeting (ISR&T) systems to fire direction systems is a recurring command and control problem that was identified to Congress this past year by the Commandant of the Marine Corps.[153] Marine Corps interest in having this capability aboard NSFS ships goes back to 1956.[154] It is also a requirement in joint doctrine.[155] In 1985, the AEGIS AN/SPY-1 Radar System demonstrated the ability off Beirut to detect ground based indirect artillery fires.[156] As recently as May 2000 the Pacific Fleet identified counter-fire capability deficiency to the Headquarters Department of the Navy.[157] The Atlantic Fleet brought it up as an issue in 2003 and 2004 but gained no traction within the Department of the Navy staff.[158] The GAO, in November 2006, further identified the capability gap with command, control and target acquisition but did not identify a lead organization to

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[153] *Report to Congress on Naval Surface Fire Support*, Commandant of the Marine Corps Attachment, 4-5. The commandant is especially concerned that NSFS be able to conduct counter battery fire on enemy artillery during a forced entry operation.

[154] James W. Hammond, III., "Counter battery from the Sea," *Proceedings* (April 1998), 31. In 1956, LtCol H.J. Woessner stated "we must have…shipboard devices similar to the existing counter-mortar radar, capable of locating the enemy weapons quickly and accurately." 50 years later, we still fail to achieve this critical capability.

[155] U.S. Joint Chiefs of Staff, *Joint Publication 3-18; Joint Doctrine for Forcible Entry Operations* (Washington: Joint Chiefs of Staff, 16 July 2001), II-2. The doctrine states that "Communications for amphibious assault operations must integrate C2 systems that control naval fire support, ship-to-shore movement, joint air operations, assault vehicle control, surface fire support, and logistics."

[156] Hammond, "Counter battery from the Sea," 31, 32. The need for this capability was demonstrated at Beirut. Any time the Marines are landed without artillery, this capability must be resident aboard ships.

[157] Memorandum from Director Fleet Warfare Requirements, Pacific Fleet to Chief of Naval Operations (N83), Subject: Counterfire Mission Needs Statement, dated 4 May 2000.

[158] Naval Afloat Targeting Integrated Process Team Position Paper prepared by LCDR Douglas D. Warner, 17 August 2004. This paper describes the work done in 1986 to build the algorithms and base data, a feasibility study in 1997 that was successful, a shipboard test in 1999 that proved the ability to locate target artillery batteries within 16 meters circular error probably. The paper also outlines how after the Pacific Fleet change of command this issue lost support with the command. Twice (2001 to 2004) there were attempts to obtain funding to finish the program. They failed. Total cost estimated by Dahlgren Naval Surface Weapons Center engineers for software upgrades to the AEGIS system for full functionality was approximately $5.8 million. Without this capability, NSFS platforms are unable to conduct effective counter battery fire against enemy artillery.

develop a solution.[159] General Hagee, then Commandant of the Marine Corps, voiced concerns with this gap to Congress in 2006.[160] In 1988, James Hammond stated AEGIS ships lacked counter battery capability, yet were required to perform counter battery as part of their share of the NSFS mission.[161] AEGIS AN/SPY-1 radar can detect a cannon projectile out to sixty-three miles, which is also the objective range threshold USMC range requirement.[162] Navy objections to this program appear to be that performance of this mission makes the AEGIS ships too vulnerable.[163] The *Iowa* Class battleships, which are considerably less vulnerable than AEGIS ships, were to receive a projectile tracking radar, similar in capability to the Army's Fire Finder suite of counter-battery radars. The upgrade was canceled in 1991.[164]

Moving targets and collateral damage - Gap 2 and Gap 3 are quick reaction, accuracy, target sensor (terminal guidance) and command and control gaps. A gun-based solution would provide options to reach the target quicker than any other potential solution except air delivered ordnance with aircraft in the target area. A hypersonic gun launched projectile using terminal guidance and warheads such as Search and Destroy Anti-armor Munition (SADARM) or Brilliant Ant-armor ammunition (BAT) reaches the target in minimum time, increasing the chances of striking a moving, fleeting target.

Volume Fires and "suppression" Gap #4: The FNA had very few missions for suppression fires.[165] The GAO stated in its most recent report concerns over the

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[159] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 4.
[160] *Report on Naval Surface Fire Support*, USMC Enclosure, 4-5.
[161] Hammond, "Counter battery from the Sea," 31. Hammond further states the U.S. Navy can either say it has a minimum NSFS capability which will include AEGIS ships and the capability to conduct counter battery fire, or the nation has no amphibious capability.
[162] Ibid., 32.
[163] Ibid., 32. An additional concern is AEGIS radar cannot perform the anti-air and artillery target acquisition at the same time.
[164] Kenneth W. Estes, LTC, USMC(ret)., "Letters," *Marine Corps Gazette*, March 2006, 6. The projectile tracking radar was part of Phase III upgrades to battleships.
[165] *Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA*, Slide 60. There were three combat phases in the major combat operations scenario. There were suppression calls for fire in Phase 1 (amphibious forced entry), two missions in Phase 2 and three missions in Phase 3. This does not

quantification of volume and suppression fires.[166] Historic needs for suppression fire can be garnered from analysis such as the Korean War era OEG 506 report and Major General Weller's 1977 report. In 1990, the Army's Human Engineering Laboratory contracted Vector Research, Inc. to conduct a comprehensive study of the effects of volume fires upon enemy combatants. This study provides a baseline of analysis to develop a quantitative measure of weapons effectiveness in suppression of enemy troops based upon the weight of explosives applied to a given target area.[167] Most of the available data is from the Second World War with additional data provided from 1970s Middle East wars and live fire experiments. The methods for gathering the data and the data's general consistency provide a start point to guide additional research in refining modeling approaches to suppressive fires.[168] U.S. Army Training and Doctrine Command's Research and Analysis Center at White Sands Missile Range (TRAC WSMR) produced and reviewed a number of predictive models of the effect of

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appear congruent with combat facing a skilled or savage enemy as outlined in numerous sources to include MG Weller's report, the OEG Study 506, and other documents referenced in this thesis

[166] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, front piece, 10-13. "Quantifiable measures are still lacking for volume of fire—the delivery of a large quantity of munitions simultaneously or over a period of time to suppress or destroy a target. Until further quantifiable requirements are set for volume of fire, it is difficult to assess whether additional investment is necessary or the form it should take."

[167] David Thompson, Robert Robillard, Dennis Wylie, and Robert Mackie, eds. *Suppression Effects Study: Volume 1 – Main Report* (Aberdeen Proving Ground, MD; U.S. Army Human Engineering Laboratory, October 1990). The document is provided in two volumes. The first volume has the basic report; the second contains the annexes that support the report.

[168] Ibid., 8-10, 16, 32, 50, 60-80. Two British analysis teams in WWII developed most of the data suitable for quantitative analysis. They focused on actions in Italy and Northern Europe. The primary focus was on indirect, high explosive fires and their effects upon enemy troops. Limited data was generated for Japanese units. The study focused on human responses to suppressive fires. The study noted that effects upon troops varied by level of training and intensity of their commitment. Suppression against German troops tended to create behavioral effects such as lack of desire to fight, where as against Japanese troops physical effects such as injury or death had to be delivered in order to achieve the overall desired effect. A basic formula of pounds per square yard of High Explosives will produce specific duration of neutralization or produces a collapse of the enemy force. There were also other considerations addressed such as timing of bombardments to ensure advancing troops were on time to assault neutralized positions. Page 76 identifies the number of 155mm projectiles in one hour for personnel in slit trenches in a specific sized area in meters to produce a neutralizing effect length after the shelling stops. The more shells fired, the longer the neutralization effects last.

suppressive fires upon troops and they are addressed in the study.[169] Additional quantitative data is provided in the second volume of the suppression study.[170] The GAO identified the need for greater analytics behind the volume fire requirement. This can likely be met by expanding the Vector Research analysis. Volume fires require lethal munitions, which in certain situations require balance with collateral damage concerns.

Lethality and collateral damage: Collateral damage was mentioned eighteen times in the ICD, yet lethality was mentioned only once. Hard targets were not addressed. While collateral damage considerations are high for the Joint Force Commander, the impact due to a lack of lethality can be even higher if it results in failed missions and coalition force deaths. Lethality deserves greater consideration than it has received. Chapter 5 addresses lethality in greater detail.

Status of NSFS requirements: The GAO stated in 2006 that the Navy and Marine Corps have reached agreement on requirements for NSFS.[171] While the December 2005 Initial Capabilities Document (ICD) was identified as the new requirements document in the GAO report, the Marine Corps Combat Development Command (MCCDC) stands behind the 2002 requirements document. MCCDC apparently has not concurred that the ICD is the new NSFS requirements benchmark.[172]

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[169] Ibid., 251-285. Additional information is provided on counter battery suppression fires on pages 289-296. This information included data from the Yom Kippur War, 1973 Arab Israeli War, and Korea.

[170] Ibid., In addition to quantitative data on the TRAC-WSMR models, there is additional information on the British sources and abstracts from WWII, a behavioral science review, and descriptions of the Army Combat Developments and Experimentation Command (CDEC) and Litton Corporation's experiments in suppression. Significant quantitative data is provided in this material. Though dated, it provides a good start point for additional analysis.

[171] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 7-8. The GAO states "Although the Marine Corps further defined its needs for naval surface fire support over the last ten years, it only recently reached agreement with the Navy on a new set of requirements through the Joint Capabilities Integration and Development System, a joint process for establishing requirements. This process resulted in the Joint Fires in Support of Expeditionary Operations in the Littorals Initial Capabilities Document, which incorporated and validated the Marine Corps's requirements for naval surface fire support."

[172] *Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA*. Slide 3 notes state "This analysis will establish those operational tasks, conditions and standards from which follow-on analyses can determine the adequacy of equipment, technology and tactics to provide joint fires capabilities for

This makes sense given the ICD's focus on capabilities gaps as opposed to a holistic documentation of the panoply of NSFS requirements.

Summary: The ICD does not account for volume fires in a coherent manner. It included very few targets, and none were fully defined in the FNA documentation. Hard targets did not appear to include field fortifications, bunkers and tunnels. The bulk of the Joint Fires in the ICD analysis appears to be provided by aviation assets. Lack of definitive shooter-target weapon specific documentation in the analysis, the prevalence of aviation weapons, and the known small magazine capacities of the ships mounting NSFS guns suggests a low participation of gun based NSFS systems. The Army has reduced organic artillery in anticipation of "joint fires" which increases the overall requirement for non-organic Army fires. The USMC originally called for a gun solution, yet that requirement basically disappeared. The solution for Gap #1 (targeting) currently has no sponsors that have accepted the mission to find a solution.[173] The JCIDS process is not in a position to solve this problem without the authority to task the services to identify a sponsor. Volume fires and lethality are risk evaluation criteria in Chapter 8 of this study.

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maneuver forces operating in the littorals." It does not state specifically that it will establish the NSFS requirement.

[173] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 4; Interview, Commander Bryan Clark, 21 November 2006. CDR Clark further stated, "Solutions to the gaps, however, have focused mainly in the lower priority gaps of the Joint Fire ICD - all areas requiring improvements to the volume and precision of joint fires. Improvements to the C2 of Joint Fires and better linkage of C2 to improved Battlespace Awareness have not been pursued aggressively by potential sponsors." This indicates the JCIDS capabilities gap solution process is consensus based and if a sponsoring service does not want to solve the gap, there will be no movement towards a solution.

> *"Here we are in the year 2002, fighting the first war of the 21st century, and the horse cavalry was back and being used, but being used in previously unimaginable ways. It showed that a revolution in military affairs is about more than building new high tech weapons, though that is certainly part of it. It's also about new ways of thinking, and new ways of fighting."* - Secretary of Defense Rumsfeld [174]

Chapter 5: Alternatives, Considerations and Options

Over the past forty years a number of initiatives were undertaken to improve the performance of naval fire support. Some of these efforts involved major caliber guns. This chapter provides an overview of those efforts and their level of success. Additionally, this chapter reviews major caliber gun lethality, the utility of capital surface warships, and recent alternative proposals to bring significant NSFS to the fleet on a large surface warship.

Previous work on major caliber gun long-range munitions: It is often claimed that major caliber guns are not capable of reaching the ranges required by the Marine Corps and that the U.S. must pursue new gun systems.[175] Past work, however, shows that this is not the case. In two separate periods of time the Navy developed long range projectiles for 16-inch guns, once during the late 1960s, and the other during the 1980s.

Project "Gunfighter" was a Navy effort to extend the range of all naval guns from 5-inch to 16-inch. This program of record developed a long-range 8-inch projectile used in combat during the Vietnam War.[176] For the 16-inch rifle, the Army's 600-pound/280-mm atomic cannon projectiles were the basis for a long-range sabot-launched projectile.[177] Firings in the 1968-69 period demonstrated ranges of up to fifty nautical

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[174] Arthur K.Cebrowski, *Military Transformation: A Strategic Approach* (Washington, DC: Department of Defense, 2003), 9.

[175] *Issues Related to Navy Battleships*, 14; Irwin, "Marines Clamor for Long-Range Artillery at Sea."

[176] Muir, *Black Shoes and Blue Wate*, 167; Interview, James Edwards, 24 November 2006, former senior engineer of Gunfighter program. During the last tour of the USS *Saint Paul*, she fired the 8-inch long range projectiles against Viet Cong positions to ranges over 35 miles – 60,000 yards - inland. Additionally, a 5-inch rocket assisted projectile with a range of over 23,000 yards was fielded and fired against the Viet Cong in February 1970.

[177] A Sabot is a thrust-transmitting carrier that positions a missile in a gun barrel or launching. See Merriam-Webster dictionary, accessed 22 March 2007 at http://www.m-w.com/dictionary/sabot; A sabot is

miles.[178] The program's final report includes the cancellation letter from the Vice Chief of Naval Operations, dated 22 September 1967. The letter cites high risk for existing fuses, requiring an investment of up to $5 million, as well as flight stability and sabot separation problems.[179] These statements were made *prior* to the first firings in November 1968. Test firing of the fuses were satisfactory.[180] Testing of the sabots indicated minor problems with the driving (rotating) bands on the sabots and that higher quality materials (brass and copper) would improve the reliability.[181] Of interest, is the amount of money programmed as opposed to that actually spent. The final report cites total costs as $225,000 for all materials and expenses.[182] The memo signed by the Vice Chief of Naval Operations stated that $1.05 million was programmed just for the use of the Wallops Island Test Range.[183] This program resulted in successful firings of a large caliber projectile that exceeds by ten nautical miles (nm) the current Marine Corps' minimum (threshold) range requirement of forty one nm, and is just short twelve nautical miles from the objective range of sixty-three nautical miles.[184] Current advances in guidance and fuse technology can be applied to this projectile to further increase its accuracy and resulting lethality.[185] Improvements in ballistic shape (such as the "Moore shape" designed by Dr. Frankie Moore of Naval Surface Warfare Center, Dahlgren also

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a sleeve placed around a projectile so that it can be fired from a weapon with a larger bore. The sabot drops away shortly after the projectile is fired. See Encarta Dictionary accessed 22 March 2007 at http://encarta.msn.com/dictionary_/sabot.html.

[178] U.S. Department of the Navy, *Indian Head Technical Report 289: 16-inch, 280mm Spin-Stabilized Sub-caliber Round Feasibility Program: Final Report (U)* (Indian Head, MD: Naval Ordnance Station, 30 April 1969), 1.

[179] Ibid., App A.

[180] Ibid., 9.

[181] Ibid., 10.

[182] Ibid., 1.

[183] Ibid., App A.

[184] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 2.

[185] U.S. Department of Defense, *Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace* (Washington, DC: Department of Defense, October 2004), 29-30; J.R. Wilson, "Smart munitions development relies heavily on MEMS technology," *Military & Aerospace Electronics*, January, 2003; "ATK advances guided-artillery project," *United Press International*, 11 July 2006. "ATK, BAE SYSTEMS Compete On Artillery Precision Guidance Kits," *Defense Daily*, Vol. 231 No. 5, 11 July 2006.

improves fragmentation pattern) can increase the range to approximately 100 nautical miles.[186]

Figure 1: 280mm Sabot projectile[187]

During the 1960s and early 1970s, the Navy and the Army undertook extensive experimentation and analytic effort for advanced long range projectiles. There were additional designs for long-range 16-inch gun munitions. These included a 460 pound, 50 nautical mile "dart" shaped 8-inch diameter fin stabilized projectile, a 1,500 pound, 100 nautical mile rocket assisted projectile, and a 278 nautical mile (320 statute mile) high mass fraction rocket assisted spin stabilized projectile with a 540 pound warhead.[188] The

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[186] Edwards interview, 24 November 2006 and Tom Doran, 14 December 2006.

[187] Photo provided by James Edwards.

[188] The technical data for these projectiles was provided by James Edwards. The first projectiles were sixty-five inches long and could be stored and loaded using the existing munitions handling equipment (hoists and shell storage decks) on an *Iowa* class ship. The 100 mile rocket assisted shell was approximately twenty inches too long to work within the existing handling system. The 278 mile rocket assisted shell was fourteen inches too long for the *Iowa* class ship's ammunition handling equipment. However, if shortened to seventy-six inches, this projectile could likely achieve a maximum range exceeding 200 nautical miles.

Navy demonstrated projectiles with a "dart like" appearance during the Vietnam conflict with the long-range 8-inch bombardment munition.[189]

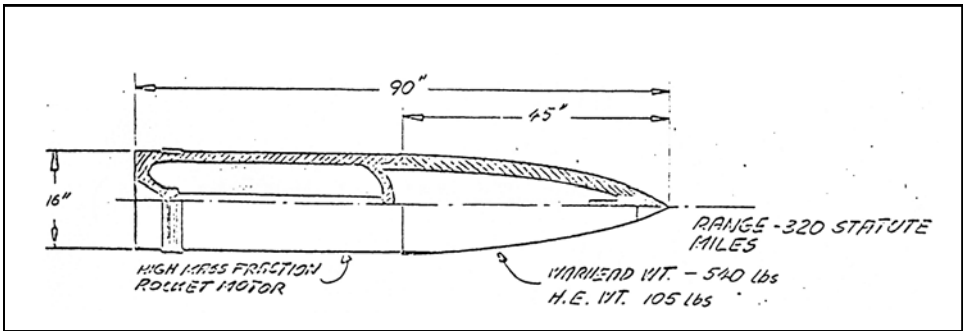

Figure 2: Rocket Assisted 90-inch long, 16-inch diameter, 278 Nautical Mile range projectile.[190]

This work clearly shows an ability to meet current threshold and objective fire support requirements of the Marine Corps with existing 16-inch gun assets. Use of modern guidance systems such as the "Precision Guidance Kit" (PGK) can greatly increase the accuracy of these types of munitions.[191]

The EX-148 extended range 16-inch sabot projectile was developed under the Navy's 16-inch Naval Gunfire Improvement Program (project number S-1894) with initial funding provided in Fiscal Year 1986.[192] It was designed primarily as a submunitions cargo projectile to provide greater lethality over a larger area than

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189 Edwards interview.

190 Drawing from "Gunfighter Program" provided by James Edwards. This projectile was 14 inches too long to be served by the *Iowa* Class ships munitions handling equipment. Shortening the projectile would have reduced range by at least 50 miles.

191 The FY2007 President's Budget includes funds to further develop the Precision Guidance Kit (PGK). The budget exhibit explaining the program was accessed on 20 December 2006 at http://www.js.pentagon.mil/descriptivesum/Y2007/Army/0604802A.pdf (page 21). The Army will monitor the Navy's Guidance Integrated Fuse (GIF) program for progress, and may terminate its development efforts should the GIF program achieve an affordable design before PGK. GIF progress will be considered at the various acquisition milestones allowing the Army to either chose the GIF or to continue developing PGK with the Army contractor. One of the two Army demonstration contractors, Raytheon, has successfully tested a version of the PGK which is described in a press release accessed on 20 December 2006 at http://www.prnewswire.com/cgi-bin/micro_stories.pl?ACCT=149999&TICK=RTN&STORY=/www/story/05-16-2006/0004362798&EDATE=May+16,+2006. General information from Picatinny Arsenal program manager was accessed on 20 December 2006 at https://picac2cs9.pica.army.mil/AdvancedSystems/ProductInformation/PgkPrecisionGuidanceKit.aspx.

192 U.S. Department of the Navy, *NavSWC TR 91-793: Engineering Development of the 16-inch Extended Range Projectile EX-148 Mod 0: Final Report* (Dahlgren, VA: Naval Surface Warfare Center, March 1992), 9.

conventional unitary blast warheads.[193] The planned projectile warhead consisted of 555 fist-sized Improved Conventional Munition (ICM) M46 bomblets.[194] This projectile could be fielded as a unitary blast fragment warhead with approximately a 140 pound high explosive load.[195] While achieving a range of approximately thirty-five statute miles, this projectile was approximately ten miles short of the range required to meet the USMC threshold requirement. An improved shape would have achieved forty-one nautical miles.[196] With part of the Marine Corps forty-one nautical mile range requirement consisting of a twenty-five nautical mile standoff from shore, a well-protected ship closing within five miles of the shore would exceed the USMC threshold inland requirement of sixteen miles by almost twenty miles.[197] Applying an improved ballistic design, the EX-148 could be fired to ranges in excess of forty-one nautical miles, meeting the USMC threshold requirement.[198] This projectile weighs about 950 pounds without the sabot. The EX-148 was test fired and proven feasible. Additional testing would have been required prior to production and fielding to the fleet. [199]

Scramjet: Additional options have also been proven feasible, though without direct testing in a major caliber gun. In 2003, the Pratt and Whitney Company, working with Dr. Dennis Reilly, a plasma physicist with extensive experience with munitions, conceived a 400 nautical mile range scramjet propelled 16-inch projectile. Initial analysis indicated the projectile had a 9-minute time of flight to maximum range.[200]

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193 Ibid., 10.
194 Ibid., 21.
195 Doran interview.
196 Doran interview.
197 *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 6.
198 Doran interview.
199 *NavSWC TR 91-793: Engineering Development of the 16-inch Extended Range Projectile EX-148 Mod 0: Final Report*, 9-11, 43. Tests proved the concept sound, with basic selection of sabot design, range, and payload confirmed and required following testing and design directions confirmed.
200 Interview, Dr. Dennis Reilly, 18 October 2006; Dr Reilly provided a copy of a 3 January 2003 letter to Dr. William Stearman, from Pratt and Whitney, signed by Joaquin H. Castro, which laid out the basic performance in range of 400 nautical miles (460 statute miles) and time of flight of 9 minutes with an

Unfortunately, the Navy had no interested sponsor according to both Pratt and Whitney representatives and Dr. Reilly.[201] The basic design of a scramjet-powered gun-launched projectile has been proven feasible by recent firings of the Army's proposed 120mm gun-launched scramjet projectile.[202] The design applied to larger projectiles and coupled with Pratt and Whitney's initial research, provides an opportunity to explore the capability a 400 nautical mile projectile brings to the Combatant Commander for lethal, deep penetrating precision fires. Currently, Alliant Techniques is developing a ram-jet projectile for 5-inch and 155mm guns.[203] The significance of this effort is the feasibility to apply to any type of projectile.

Current efforts with major caliber possibilities: The electromagnetic rail gun concept currently under development provides another option to field a major caliber gun with significant capability at some point in the distant future.[204] Though not likely to reach initial operating capability before 2020, this technology could provide a future capital surface warship with the long reach of a major caliber gun while using the space

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impact velocity of 2,800 feet per second as feasible. Both Dr. Reilly and Mr. Castro stand behind the initial estimate as a good start point to assess potential capabilities of a 16-inch gun launched scramjet projectile.

[201] Interview, Dr. Reilly, 5 December 2006.

[202] "120mm Mid-Range Munition (MRM)," *GlobalSecurity.org*, accessed on 14 December 2006 at http://www.globalsecurity.org/military/systems/munitions/mrm.htm; Frank Colucci, "Army Tests Scramjet to Power Kinetic Energy Tank Rounds," *National Defense*, August 2003, accessed 14 December 2006 at http://www.nationaldefensemagazine.org/issues/2003/Aug/Army_Tests.htm. These tests prove that a gun launched scramjet projectile is now a reality.

[203] "ATK Mission Systems is developing the ramjet propulsion system for the Very Long Range Munition – Air Breather (VLRM-AB) ramjet-assisted artillery projectile. Assisting guided projectiles with ramjet propulsion will enhance platform survivability by increasing standoff range and improve call-for-fire responsiveness through shorter flight time. VLRM-AB for 155mm artillery provides the U.S. Army with extended-range fire capability, precision, and lethality. VLRM-AB can facilitate the long-range naval surface fire support…155mm projectiles for the Navy's Advanced Gun System." See full article accessed 21 March 2007 at http://www.atk.com/Customer_Solutions_MissionSystems/cs_ms_w_hs_vlrm-ab.asp.

[204] "NAVSEA Touts Recent Low-Energy Test for Rail Gun Program," *Inside the Navy*, October 16, 2006. This article provided the following additional information: RADM Barry McCullough, director of the Navy's surface warfare requirements directorate, told *Inside the Navy* through a spokesman, that a ship-based rail gun is not anticipated to be ready prior to the 2020 to 2025 time frame. However, the following prepared statement by NSWC Dahlgren Commander CAPT Joseph McGettigan identifies the potential of the naval rail gun: "With the potential to deliver lethal, hypersonic projectiles at ranges in excess of 200 nautical miles within six minutes, a naval rail gun offers a transformational solution for volume fires and time-critical strike."

required for storing propelling charges for additional projectiles. Doing so would double the available number of projectiles aboard ship given no requirement to store propellants.

Lethality considerations: A detailed discussion of current precision weapons lethality is not possible in an unclassified environment (see classified Appendix H). Older declassified penetration and general fragmentation pattern data is still relevant for discussion. Even assuming all future gun-launched projectiles are precision guided, the larger shells are often inappropriate when there are collateral damage concerns. VADM (ret) Cerbrowski, the former head of the Department of Defense Office of Force Transformation, stated there is a growing need for "large volume precision strike" and "prompt precision strike."[205] Guns complement airpower, which is especially important in a target rich environment against determined and resourceful foes. The fragmentation patterns below resulted from guns firing at 15 degrees elevation. Airburst fuses will provide different pattern sizes and shapes, but similar in magnitude (i.e., size of shell produces a certain size pattern) lethal area differences.

Projectile	Length	Width
5-inch	75-150	70-120
6-inch	125-150	95-170
8-inch	200-450	150-275
12-inch	400-800	225-500
16-inch	500-1000	300-600

Table 3: Fragmentation Patterns on Water by base detonating fused projectiles[206]

The following charts related to penetration for bombs and projectiles. High explosive shells tend to fracture upon concrete at velocities greater than 1,700 feet per second unless the walls of the shells are strengthened.[207]

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[205] Stuart E. Johnson and Arthur K. Cebrowski., *Alternative Fleet Architecture Design* (Washington, DC: National Defense University, August 2005), 14.
[206] *Ordnance Pamphlet 1172: Performance of Bombs and Projectiles Against Shore Installations,* 56.
[207] Ibid., 13.

Horizontal Bombing penetration of 5000 psi concrete				
Altitude (Ft)	500 lbs AN-M58	1000 lbs AN-M59	1000 lbs AP Mk 33	1600 lbs AP Mk-1
5,000	2.0	3.0	3.5	4.0
10,000	3.0	4.0	5.0	6.0
15,000	3.5	5.0	6.0	7.0
20,000	4.0	5.5	6.5	8.0
25,000	4.0	6.0	7.0	9.0

Table 4: Horizontal bombing penetration of 5000 pounds per square inch concrete.[208]

Table 4 provides unclassified insight to bomb performance against concrete.

6-inch AP (Common) - 105 pounds				
Initial Velocity - 3,000 fps (Range Table OP1112.)			Feet of Reinforced Concrete Penetrated	
Range Yds	Angle of Fall (Degrees)	Striking Vel. (Feet Per Sec)	0 Degrees Impact Obligity	30 Degrees Impact Obligity
2,000	1	2,655	7.0	5.5
6,000	3	1,055	5.0	4.0
10,000	7	1,580	4.0	3.0
15,000	18	1,192	3.0	2.0
20,000	34	1,073	2.5	2.0
25,000	49	1,111	2.5	2.0

Table 5: 6-inch armor piercing projectile penetration data[209]

Tables 5 and 6 show smaller caliber (6-inch) projectiles lose velocity faster than larger projectiles and their penetration is much less than larger projectiles. Larger caliber projectiles demonstrate greater penetration at long range, and maintain velocity at longer ranges than do the smaller projectiles. The 12-inch projectile shown below makes a good comparison with the long-range 16-inch EX-148 sabot and 280mm sabot in terms of weight and size. Sabot launch gives terminal velocities higher than indicated below.

12-inch Armor Piercing projectile - 870 pounds				
Initial Velocity - 2,900 fps (Range Table OP 169)			Feet of Reinforced Concrete Penetrated	
Range Yds	Angle of Fall (Degrees)	Striking Vel. (Feet Per Sec)	0 Degrees Impact Obligity	30 Degrees Impact Obligity
2,000	1	2,694	19.5	14.5
6,000	3	2,318	15.5	12.0
15,000	11	1,671	10.5	7.5
20,000	18	1,445	9.0	6.5
30,000	39	1,268	7.5	5.5
34,000	47	1,303	8.0	6.0

Table 6: 12-inch Armor Piercing projectile unclassified penetration data[210]

[208] Ibid., 10.
[209] Ibid., 18.

16-inch Armor Piercing projectile - 2,700 pounds				
Initial Velocity - 2,500 fps (Range Table OP 770)			Feet of Reinforced Concrete Penetrated	
Range Yds	Angle of Fall (Degrees)	Striking Vel. (Feet Per Sec)	0 Degrees Impact Obliqity	30 Degrees Impact Obliqity
2,000	1	2,409	36.0	27.5
10,000	6	2,074	27.5	20.5
20,000	15	1,740	21.0	15.5
30,000	28	1,567	18.5	14.0
35,000	36	1,556	18.0	13.5
40,000	45	1,607	19.0	14.0
42,345	53	1,686	20.0	15.0

Table 7: 16-inch Armor Piercing projectile unclassified penetration data[211]

The 16-inch projectile shows even greater penetration and less loss of velocity as the range increases than the smaller projectiles shown above. Velocity is one of the attractive potential capabilities of the electromagnetic rail gun or a scramjet projectile whose terminal velocities are two to four times that of normal gun projectiles.[212] Table 8 shows a general increase based upon declassified penetration data velocities at impact compared to the recently released Navy data on rail gun velocities at the muzzle and upon impact. Linear scaling factors indicated by Table 8 are likely understated assuming hard armor piercing projectiles impacting at less than 20 degrees of obliquity.[213]

Projectile	Existing Vel	Penetration	Rail Gun Vel	Penetration
6-inch Armor Piercing 105 lbs (2k yds)	2,655	7.0	7,500	19.7
6-inch Armor Piercing 105 lbs (25k yds - author)	1,111	2.5	3,093	7.0
6-inch Armor Piercing 105 lbs (Navy data)	N/A	N/A	5,500	12.4
12-inch Armor Piercing 870 lbs (2k yds)	2,694	19.5	7,500	54.3
12-inch Armor Piercing 870 lbs (34k yds - author)	1,303	8.0	3,628	22.3
12-inch Armor Piercing 870 lbs (Navy data)	N/A	N/A	5,500	33.7
16-inch Armor Piercing 2,700 lbs (2k yds)	2,409	36.0	7,500	112.1
16-inch Armor Piercing 2,700 lbs (42k yds - author)	1,686	20.0	4,694	55.7
16-inch Armor Piercing 2,700 lbs (Navy data)	N/A	N/A	5,500	65.2

Table 8: Comparison of standard and estimated rail gun penetration of concrete in feet (see notes below)[214]

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[210] Ibid., 21. EX-148 muzzle velocity 3,400 feet per second. Interview, Thomas Duran 7 December 2006.

[211] Ibid., 26.

[212] Michael Zitz, "Navy railgun causes buzz," *The Free Lance-Star*, 11 February 2007, A1, A11. Muzzle velocity cited is Mach 7 or about 7,700 feet per second. Impact velocity is estimated at Mach 5 or approximately 5,500 feet per second. The speed of sound (1 Mach) is 1,100 feet per second as quoted at http://www.grc.nasa.gov/WWW/K-12/airplane/sound.html accessed on 18 February 2007.

[213] National Defense Research Committee, *Summary of Technical Report of Division 2, NDRC: Volume 1: Effects of Impact and Explosion* (Washington, DC: Columbia University Press, 1946), 221-220, 393.

[214] *Ordnance Pamphlet 1172: Performance of Bombs and Projectiles Against Shore Installations*, 18, 21, 26. The existing velocity was extracted from the OP 1172. Michael Zitz, "Navy railgun causes buzz," *The Free Lance-Star*, 11 February 2007, A1, A11. The rail gun velocities cited in the article were 7,500 fps at

The Navy envisions a rail gun firing 10 rounds per minute with a 64-megajoule (mg) gun.[215] The chart above provides an indication of the size of a major caliber rail gun projectile and the level of penetration it can potentially achieve to take full advantage of the rail gun's capabilities. While these estimates are very rudimentary, they indicate the possibilities of a large caliber rail gun's penetration and power.

Gun	Projectile	Proj Wt (lbs)	Muz Vel (feet/sec)	Muzzle Engy Megajoules	Comp factor
5-inch Mk 45 Mod 2	MK 80	68	2,725	10.7	1
5-inch MK 45 Mod 4	ERGM	110	2,750	17.6	2
AGS (155mm)	LRLAP	240	2,360	28.2	3
Rail Gun	inert slug	55	7,500	65.4	6
16-inch	Mk 13 HC	1,900	2,690	290.4	27
16-inch	Mk 8 AP	2,700	2,500	356.5	33
16-inch	280mm Sabot	600	3,500	155.3	15
Major Cailber railgun	Inert slug	2,700	7,500	3,208.4	301

Table 9: Comparison of gun/projectile power by megajoules[216]

The one drawback to a major caliber rail gun is the energy management issue. A gun firing at 7,500 feet per second (fps) vs. 2,700 fps generates about 27 times the energy necessary for the lesser speed. This means that a 16-inch rail gun will generate about 27 times the energy of a standard 16-inch gun.[217] This increases the technological challenges related to making a major caliber rail gun a reality, but the great capability potential makes the effort required worth exploring.

Seen earlier, the 5-inch gun uses volume to make up for lack of lethality. The 155mm LRLAP will have only slightly greater lethality than the current 5-inch gun. The

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the muzzle and 5,500 fps upon impact. However, a linear percentage reduction from the OP 1172 velocity loss averages over range indicated less terminal impact velocity. Both the Navy data in the article and the study author's calculated values are provided. These impact penetration values are a linear scale increase from the penetration values listed in the OP 1172. They are illustrative only.

[215] A joule is a unit of work or energy equal to the work done by a force of one newton acting through a distance of one meter. See Merriam Webster dictionary accessed 22 March 2007 at http://www.m-w.com/cgi-bin/dictionary.

[216] Megajoule formula provided by Tom Duran via e-mail, 13 February 2007. The formula is (projectile weight/2.2) X (muzzle velocity/3.28) x (muzzle velocity/3.28) divided by 2.

[217] Interview, Nathan Okun, 6-7 March 2007. He furthers states "two-thirds of the firing energy has to be absorbed by the gun, gun-mount, power supply, power transmission cables, power storage unit, and the ship structure during power generation and gun firing, with only one-third actually going into the projectile to accelerate it on firing."

need for a significant blast fragmentation munition is still valid.[218] The fragmentation capabilities of a major caliber projectile vice a small projectile such as 5-inch or 155mm are significant as shown in Table 3. A continuing need exists for deep-penetrating munitions and major caliber guns can meet those requirements within their range.[219]

Ammunition capacity: Chapter one cites the Marine Corps requirement for 24 total DDG-1000 warships to meet its fire support requirements. The Navy reduced its construction plan from 32 to 7 ships.

					Missions per Ship		
Ship Class	**Gun**	**Mounts**	**Guns**	**Rounds on Ships**	**8 rds per mission**	**22 rds per mission**	**40 rds per mission**
CSW (2 ships)	Major Caliber	6	18	2,400	300	109	60
" " "	5-inch ERM	12	12	8,000	1,000	364	200
Cleveland (CL) (4 Ships)	6-inch/47 Cal	16	48	12,000	1,500	545	300
" " " "	5-inch/38 Cal	24	48	24,000	3,000	1,091	600
Fletcher (DD) (7 ships)	5-inch/38 Cal	35	35	19,425	2,428	883	486
Burke (DDG) (7 ships)	5-inch/62 Cal	7	7	1,708	214	78	43
" " " "	5-inch/62 ERM			1,624	203	74	41
DDG-1000 (7 ships)	155mm AGS	14	14	4,200	525	191	105
DDG-1000 (24 ships)	155mm AGS	48	48	14,400	1,800	655	360
DDG-1000 (32 ships)	155mm AGS	64	64	19,200	2,400	873	480

Table 10: Ammunition and Mission Capacity Comparison with CSW layout similar to *Iowa* class ship.[220]

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[218] Neil F. Sleevi and Robert Mount, Briefing: *Joint Common Missile (JCM) Analysis of Alternatives,* U.S. Army TRADOC Analysis Center, Ft. Leavenworth, KS, 6 January 2004, Cited on slide #16 of the briefing contains the following citation from the 101st Airborne Division (Air Assault) Urgent Need statement, 14 March 2002: "… urgent need for blast and fragmentation warhead … for targets in fortified positions, cave/tunnel entrances, enemy defilade, bunkers/buildings, hardened command and control sites and indirect fire positions/systems, … the type of targets our units are currently facing in Operation Enduring Freedom." This statement provides a clear need for a robust blast and fragmentation projectile. While the context of the statement is a need for such ordnance that can be fired from helicopters, it still illustrates the need for the munitions effect.

[219] Joseph Jeremiah Hagwood, Jr. *Engineers at the Golden Gate* (San Francisco, CA: U.S. Army Corps of Engineers, 1980), 231-233. In the spring of 1942, the Army Corps of Engineers in conjunction with the Coast Artillery Corps, the Ordnance Department and the Navy conducted tests of 16-inch rifle penetration. The test was conducted at the Harbor Defenses of San Francisco using the recently completed Army 16-inch batteries Davis and Townsely. The test firings were against two concrete blocks 23 feet thick, one 16 feet thick and one 13 feet thick. The concrete was designed to have compression strength of 3,000 to 5,000 pounds per square inch (psi). The first test shot was expected to penetrate about 8 feet into the 23 foot block. Instead it completely pierced the block. The 16-inch gun proved a greater penetrator than originally thought; U.S. Army Corps of Engineers. *Report on Armor-Piercing Projectile Tests on Large Concrete Slabs* (San Francisco, CA: United States Army Engineer Office, 30 May 1942). This is the report of the above described firings.

[220] "…the average fire mission requires 22 rounds of 155mm LRLAP to achieve desired effects. Therefore it is assumed that the sustained or surge firing rates will be divided into individual engagements each averaging 22 rounds." Rounds per ship (magazine capacity) for DDG-1000, DDG-51 and CG-47 obtained

Table 10 shows the implications of the Navy's programmed capabilities to meet the Marine Corps volume fire requirements. Seven DDG-1000 do not provide even half of the mission capability of either ships of the past firing a competent guided munition or a potential Capital Surface Warship equipped with major caliber and 5-inch like guns. The Marines state "volume and precision fires are equally important in achieving the desired effects on an enemy."[221] There is an assumption that larger round count missions (20 and above) would be passed to aviation; however, if aviation is not available, guns will have to cover the mission.

The Capital Surface Warship (CSW): Historic precedence exists for maintaining a capital surface warship. In 1949, when fiscal constraints were most tight on the Navy, the Chief of Naval Operations, Admiral Forrest Sherman, refused to deactivate thirteen heavy cruisers and the last active battleship in order to reinforce his desire for a balanced fleet.[222] During the 1980s the Navy stated to Congress the value of the *Iowa* class ships was in naval fire support, establishing and maintaining dominant maritime presence and relieving stress on aircraft carriers.[223] The establishment and maintenance of a dominant maritime presence was a key point in Admiral Harry Train's

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from *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*, 8-6, 8-7; Ammunition loads for Fletcher and Sumner class destroyers obtained from *U.S. Destroyers: An Illustrated Design History*, 190-191, 414-413; Ammunition loads for the *Iowa*, Baltimore, Cleveland and Worchester class ships provided by Mark Wertheimer (5 and 21 February 2007) of the Naval Historic Center based on Ship Ordnance Equipment Lists and an undated (estimate about 1950) draft copy of Naval Warfighting Instruction Publication 221, Naval Gunfire Support in Amphibious Operations; Average for 155mm LRLAP was about ten per mission, and 5-inch averaged between twenty-four to forty-three rounds per mission. In the chart above, the eight rounds per mission estimate was the average between the 155mm average and the 8-inch/16-inch average. The forty round average was a combination of field artillery unclassified training estimates and the 5-inch expenditures in the CNA COEA. The average rounds per mission in the CNA COEA for 8-inch and 16-inch guns were five to seven rounds. See CNA, *NSFS COEA Final Report*, 90. Data declassified 8 February 2007 by OPNAV, N86. Declassification notification maintained by Joint Forces Staff College Ike Skelton Library.

[221] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 1, 4.

[222] Muir, *Black Shoes and Blue Water*, 34.

[223] U.S. Congress. Senate, Senator Strom Thurmond of South Carolina speaking for the Department of Defense Supplemental Appropriation Authorization Act, 1981. 97th Congress, 1st session,. Congressional Record Vol 127, Pt. 5,, (7 April 1981): 6602. Senator Thurmond also stated the Navy had said that additional benefits were the battleship's size and protection. Size alone provided the ability to add capability and modern weapon systems; Interview, Admiral (retired) Harry Train, 2 May 2007.

testimony to the House Armed Services Committee to reactivate the *Iowa* class ships.[224] In 1988, then Chief of Naval Operations, Admiral Trost, stated to the pre-commissioning crew of the USS *Wisconsin*:

> Put a Battleship with an Aegis cruiser and you've got something that can go anywhere in the world. Put a battleship battle group within a couple of hundred miles of a carrier battle group and you've got something no one in the world can beat![225]

The impact of adding the battleships to the fleet was not lost on Congress. It saw the reactivation of the battleships as a key tool. When assigned as the center of a Surface Action Group, it could relieve the stress on the then 12-carrier navy for peacetime presence and crisis response operations.[226] The Navy in the 1980s used the battleship as a CSW to substitute for an aircraft carrier in areas with limited air threats. However, the battleship's NSFS capabilities were of a secondary consideration to the Navy, and improvements planned did not achieve the full capabilities the USMC desired.[227] Admiral Train notes that Marine Corps support for reactivation was specifically related to the ability of the ships to greatly improve existing naval fire support capabilities.[228] Clearly, balance of employment is critical if a CSW were to be reintroduced to the fleet.

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[224] Admiral Train Interview.

[225] Robert F. Summerall, *Iowa Class Battleships: Their Design, Weapons and Equipment* (London: Conway Maritime Press Ltd, 1988), 152.

[226] Congressional Budget Office, *Building a 600-Ship Navy: Costs, Timing and Alternative Approaches.* (Washington, DC: Congress of the United States, March 1982), 65. The CBO saw the surface action groups as not only supplementing carrier battle groups, but also supporting amphibious missions and conducting coastal strike against the Soviets.

[227] Estes, 6. The letter states "The recommissioning of the four *Iowa*-class battleships in the 1980s under then-Secretary of the Navy John Lehman emphasized their employment in each of four surface action groups in war at sea (WAS) scenarios as substitutes for carrier battle groups in areas with a limited or benign air threat. The WAS operations remained separate from amphibious operations in Navy programming and doctrine, and the Marine Corps remained concerned about he limited refurbishment given the *Iowa*'s, chiefly consisting of recommissioning them with limited crews and outfitting them with as many Tomahawk launchers as possible and a limited communications suite. Only in the "out years" was the BB program to undertake Phase III upgrades to the NSFS capability, such as a 13/16-inch sabot round for longer range (still short of over-the-horizon requirements), projectile tracking radar, and a potential GPS guided projectile. Phase III was deleted in the cutbacks of 1991-92 as part of the "peace dividend." The BB program never approached what the Marine Corps desired, let alone the standing requirements. The services have changed their programs, and the requirements have become even more stringent."

[228] Admiral Train Interview. In regards to reactivation of *Iowa* class ships, Admiral Train stated "the Marine Corps supported this request primarily on the basis of the ship's potential improvement to the almost then (and current) non-existent naval gunfire support capability."

Capital Surface Warships and shaping the operational environment: The impact of a CSW with major caliber guns, significant magazine capacity and strong physical protection provides advantages and effects that go beyond mere destruction of the enemy's physical capacity. The impact on their moral strength and psyche is often overlooked or improperly interpreted. Moral forces are critical to motivation in war.[229] Though a "modeled quantitative effect" of these capabilities is difficult to design, the psychological impact of a CSW is well recorded in history. The CSW provides a robust "way" to conduct shaping of the operational environment.

In 1981 it was revealed in Congressional debate why the United States Navy decommissioned the only active U.S. battleship (USS *New Jersey*) during the Vietnam War. During the debate, John Warner, who was Secretary of the Navy at the time (now Senator Warner, R-VA), stated he was "ordered to take it out of service because its belligerency and its antagonism was impeding the progress of the peace talks."[230] Having a single warship's removal being cited as a condition to attend peace talks speaks well of its psychological impact and potential shaping effect upon current and future adversaries. The wisdom of decommissioning vice withdrawing is worthy of debate given the outcome of the conflict and since North Vietnam never protested carrier presence during the Paris peace talks.

During the Iran-Iraq tanker war of the mid 1980s, the Navy conducted operations in the Persian Gulf. Of these operations, Captain Larry Seaquist of the USS *Iowa* stated:

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[229] Carl von Clausewitz, *On War* trans. Michael Howard and Peter Paret. (New York: Alfred A. Knopf, 1993), 157-158. Clausewitz states "military activity is never directed against material force alone; it is always aimed simultaneously at the moral forces with give it life, and the two cannot be separated". Sun Tzu. *The Art of War*. Trans. Samuel B. Griffith. (New York: Oxford University Press, 1971), 63. Sun Tzu identifies five fundamental factors in war, one of which, Moral Influence, is related to the soldier's belief in his leaders. The ability to instill doubt in the opponent, negatively impact this "moral influence", such as the fear visually and physically instilled by a capital surface warship, is a combat multiplier.

[230] U.S. Congress. Senate, Senator Warner of Virginia and Senator Chafee of Arkansas speaking for the Department of Defense Supplemental Appropriation Authorization Act, 1981: 6607; Also see Muir, Malcom, Jr. *The Iowa Class Battleships* (New York: Sterling Publishing Company, Inc., 1991), 117.

> What the Navy does these days is try to influence events ashore. And that's what a battleship does….when we would sail the *Iowa* down the Strait of Hormuz during the Iran-Iraq War, all southern Iran would go quiet. We were in an active tanker war and Iran's Revolutionary Guard were steaming around in ships with rockets and shooting at ships. When we arrived, all that stuff stopped.[231]

During the tanker war, Iranian consideration that these ships are among the most survivable afloat likely influenced their decision to reduce hostile activity.[232]

In April 1981, Lieutenant General P.X. Kelley, then the first Commander of the newly organized Rapid Deployment Joint Task Force (which later transitioned into the U.S. Central Command) was invited by the Sultan of Oman, Qaboos Bin Said Al-Said., to visit his summer palace at Salalah. During a discussion on the organization and mission of the RDJTF, Sultan Qaboos brought up the subject of U.S. battleships, making reference to the fact that these were now the only warships that look like weapons of war. He emphasized this by saying that if he could put a battleship in Muscat Harbor he would never have to worry about the security of Oman.[233] In late 1991, the Sultan of Oman offered to then Secretary of Defense Richard B. Cheney to pay the operations and maintenance costs of two *Iowa* Class ships as long as one was kept in the Persian Gulf area for nine months out of the year.[234] This offer of financial support makes clear the shaping capabilities of the two battleships deployed during the Persian Gulf War left a very favorable impression upon the Sultan. This psychological impact has utility today.

In the current Global War on Terrorism, the ability to deliver raw force may have a significant effect upon the psyche of a terrorist supporting state as well as the terrorists

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[231] Miles Epstein. "The Last Battleship." *The American Legion Magazine*, March 1996, 24. In this article Captain Seaquist also stated "The times have finally caught up with what battleships should really be used for. Battleships are ideal for peacekeeping and regional conflicts with a smaller post-Cold War Navy. You get this great forward presence out of them that works well in deterring crisis."

[232] Robert F Summerall. *Iowa Class Battleships: Their Design, Weapons and Equipment,* 152. Heavy armor, torpedo defense system, watertight subdivision and systems redundancy, they are not easily defeated by conventional weapons, including most missiles.

[233] Interview, General (retired) Paul X. Kelley, 20 February 2007.

[234] Interview, Samuel Loring Morison, 7 November 2006; Mr. Morison has certified in writing to the veracity of his claim. He was not aware of a formal answer in return from the U.S. Government to the Sultan.

themselves. The most interesting example of this effect was during the hijacking of Flight 847 on 14 June 1985. During this hijacking, the Hezbollah terrorists ran through the cabin yelling "Marines" and "*New Jersey*." [235] Shortly after the destruction of the Marine barracks by a suicide bomber attack, the USS *New Jersey* fired 270 projectiles against Syrian artillery positions, destroying or neutralizing all of them.[236] The effectiveness and relative invulnerability of these ships with their 19,000 tons of armor likely fueled the hijacker's anger.[237]

The impact of major caliber shells has a unique shaping effect. There are recorded instances where large shells created a greater impact upon the moral strength of both civilians and troops than bombs. The demoralization capability of these weapons is significant as well as their ability to destroy machinery given the large fragments produced by their shells.[238] Even the impact of a non-exploding shell can result in a very negative effect upon the enemy's moral strength.[239] This capability was demonstrated as recently as the 1991 Persian Gulf War. During that conflict there were occasions when Iraqi soldiers abandoned their positions and/or surrendered to an Unmanned Aerial Vehicle (UAV) spotting major caliber naval gunfire.[240]

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[235] Though the article primarily address the hijacking itself, the impact of the shelling from 16-inch guns upon the terrorists was not lost upon the article's author. See Major Ron Eschmann, "Terror on Flight 847." (*Engineer*, July-September 2004), 39.

[236] On 8 February 1984 the USS *New Jersey* fired 270 rounds against Syrian artillery positions after the bombing of the Marine Barracks in Beirut, stopping the Syrian bombardment of Christina positions. Intelligence obtained after the bombardment confirmed the elimination of eight Syrian artillery batteries from the Syrian military. See Lehman, 327.

[237] Ibid., 309. It was assumed during the deployment that the ship could stand close to shore and protect the Marines despite the dangers of land-based cruise missiles, suicide boats and artillery.

[238] Riley, 55-57.

[239] North Korean POW's cited 16-inch shells specifically as reasons to surrender. One prisoner stated his political officer told him the UN was firing "Atomic Shells" because of the size of the craters that 16-inch shells made. Another North Korean POW told his interrogator that he made the decision to surrender when many of his fellow soldiers were killed during a bombardment, and one shell, a 16-inch HE, landed near his position and failed to explode. The shell's size convinced him it was time to surrender. See Riley, 57, 133.

[240] *Conduct of the Persian Gulf War*, 262, 273, 396, 807-808. Page 262 states "Over Faylaka Island, USS Wisconsin's UAV recorded hundreds of Iraqi soldiers waving white flags, the first-ever surrender of enemy troops to an unmanned aircraft." Another statement in the report follows on page 273. "USS *Missouri's*

The impact of major caliber naval fires upon the enemy was illustrated in the following discussion related by Mr. Charles E. Myers, Director for Air Warfare, Office of the Secretary of Defense (1973-87):

> During the post Desert Storm hassle about the Navy's unexpected decision to remove the *Iowas* from the active fleet, a Congressional staff member and I visited the head of Expeditionary Warfare (N75) who happened to be Major General Jim Jones, later Commandant of the Marine Corps and current SACEUR (Supreme Allied Commander Europe). In discussing the proposed fate of the BBs re the need for fire support, I ventured into my usual speech about the fire support potential of the *Iowas* relative to the current lack of capability (worse now, by the way based on Jones' later testimony). Jones raised his hand, cutting me off, and said: "You don't need to spend any time on convincing me of the need and value of the battleships. I'm only here today because of the fire support we received when we found ourselves in a tough spot in Vietnam." He then proceeded to tell the story of how an immediate and unexpected response to his call for help from the USS *New Jersey* saved him and his guys. Then he took a sheet of paper and sketched the East coast of Vietnam, placed a dot representing a BB near the coast from which he drew a piece of pie representing a 24 mile arc of fire for 16" guns. He explained that, from his experience, "Within that arc, the WAR evaporates; the enemy quickly learns that there are better places to be and things to do than to serve as a target for these fires that actually alter the terrain."[241]

Naval Aviation and NSFS. In response to Navy disaffection with the NSFS COEA, CNA provided a response to the Navy in 1996, which identified additional issues with aviation assuming the entire NSFS mission.[242] The response stated the cost analysis portion could not be compared to that for guns and missiles due to issues such as weather, intensity of air defenses, aircraft losses and competing missions.[243] In the detailed analysis, if aircraft losses are on the order of Desert Storm, and it is assumed two landings per day minimum, the wartime costs for Tactical Air are similar to NSFS total gun system life cycle cost. This cost includes peacetime munitions and cost to replenish

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NGFS contributed to maintaining the credibility of the amphibious assault option, particularly after a 16-inch bombardment of Ras Al-Qul'ayah induced the Iraqi defenders to abandon fortified positions."

[241] Interview, Mr. Charles E. Myers, 5 March 2007.

[242] Center for Naval Analysis, Memorandum for Major General H. W. Jenkins (N85) and Mr. Ronald Kiss (DASN (Ships)), Co-Chairs, NSFS COEA. Subject: Naval Surface Fire Support (NSFS) COEA. 14 January 1994; Interview, Robert Sullivan, 7 November 2006.

[243] Ibid., 1. The first page of the memorandum addressed these four points. The rest of the report provides additional detail on these points. Basic cost analysis of aircraft involves numbers of landings in the life of the aircraft. A heavy Close Air Support requirement would drive that number higher than programmed. That number, coupled with any combat losses, would drive the cost to extremely high levels. Another issue affecting accuracy was the cost of captured pilots and loss of flexibility.

projectiles expended in two major regional conflicts which totals about $1.3 billion. However, if losses are similar to those during the Vietnam conflict, where the U.S. maintained air superiority, the cost doubles.[244] This analysis is further complicated by how the Navy would choose to justify the increased missions for close air support. If the Navy accepts the additional mission without a growth in aircraft requirements, they could be accused of having excess force structure or otherwise having an invalid force structure requirements basis.

The analysis of aircraft responsiveness indicates that tactical air does not meet all requirements at all times. Many factors can prevent aircraft response besides not being on station when the call for fire is received. The most significant are weather and anti-air weapons.[245] Even in OIF, weather interfered with aviation-delivered fires in close support of troops.[246] Admiral Sharp states that in Vietnam, from mid-December to late May, aircraft were limited to ceilings of 6,000 feet with solid overcast above. For visual recognition, pilots have to fly at altitudes of 4,000 to 6,000 feet, making them very vulnerable to ground fire.[247] The ability to penetrate through cloud cover using modern sensors has improved markedly; however, weather can still greatly disrupt air support.[248] During air support operations in Kosovo (1999), weather affected approximately 50% of the strikes by preventing below-the-clouds close air support.[249] In Operation Iraqi

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[244] Ibid., 5-7.
[245] Ibid., 8.
[246] "Iraq Lessons: The More Things Change…" *Newsletter Of The Sea Power Centre Australia*, Issue 6, August 2003. "Not only did poor weather and competing tasks restrict the use of tactical air support during the RM assault, but Iraqi beach mining also hampered the landing of artillery and light armour. As such, the four warships poised offshore undertook a more vital than expected role, providing highly accurate and responsive indirect fire for 48 hours rather than the originally planned 24."
[247] Admiral U.S. Grant Sharp, *Strategy for Defeat: Vietnam in Retrospect* (San Rafael, CA: Presidio Press, 1978), 66-67.
[248] Anthony H. Cordesman, *The Lessons and Non-Lessons of the Air and Missile Campaign in Kosovo* (Washington, DC: Center for Strategic and International Studies, 17 September 2003), 44. Weather negatively affected airfield and tanker operations, and reduced operations 30% to 50%.
[249] Hunter Keeter, "Jones Sets Priorities For Air-, Land-, And Sea-Based Fire Support." *Defense Daily*; 18 January 2000, 5. General Jones, then Commandant of the Marine Corps, stated that bad weather was a

Freedom (OIF), weather reduced the availability and effectiveness of close air support to troops-in-contact. During this time, artillery provided tactical fires near troops.[250] During OIF, weather and competing tasks increased the requirement for coalition naval gunfire during operations at Al Faw.[251] The Australian Navy further stated with apparent dissatisfaction,

> The USN had employed battleship NGS (naval gunfire support) with considerable effect in 1991, but by 2003 the battleships had long gone and the USN had built up a measure of institutional resistance to the task, preferring instead to rely on air delivered weapons. Reinforcing this perception, the USN's cruisers and destroyers, although still mounting a 5-inch gun, were physically and operationally unsuited to the navigational constraints of Iraqi coastal waters. The RAN and Royal Navy, by contrast, gave an NGS capability far more prominence and possessed ships in the Gulf ideally suited to the mission.[252]

The CNA analysis points out that NSFS ships are very responsive and can be on station for days. Aircraft, however, are limited to a few hours and sometimes, even minutes on station without extensive air refueling. Significantly, even at an Alert-5 launch, aircraft never meet the ten-minute response time required by the Marines. Dedication of aircraft carriers to fire support is difficult to ascertain; however, at least one, and likely two or three will be required in addition to those required for air

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major inhibitor of close air support and that naval gunfire and artillery were key in closing that gap; Cordesman. *The Lessons and Non-Lessons of the Air and Missile Campaign in Kosovo*, 43-46, 110,121, 210, 265, 288-289, 297, 307, 310, 312-312. This documents 300 plus pages are permeated with information on the effects of weather on air delivered ordnance and precision-guided munitions. Adverse weather greatly complicates targeting and delivery of air delivered ordnance. This is even more difficult if the enemy has any competence at applying camouflage, concealment and deception. Foliage and weather penetrating sensors are identified as future priorities. GPS, while already the guidance system of choice in foul weather, can suffer heavily from weather intensified target location errors. Weather affects naval air delivered ordnance in many ways, from bad weather at sea slowing or stopping air operations, to inability to get a visual or laser lock on a target, to identifying the target.

[250] Scales, "Artillery's Failings in the Iraq War," 44. This article addresses both the impact that weather can have on close air support and the greater than expected use of artillery while attacking through sand storms. The amount of munitions used is well illustrated by the fact that helicopters were required to deliver over 3,000 rounds of artillery munitions to artillery advancing upon Baghdad. MG Scale's major point was artillery needed longer range and more precision guided projectiles. If this applies to artillery, it would also apply to naval fires, to include naval gunfire.

[251] "Iraq Lessons: The More Things Change…" *Newsletter Of The Sea Power Centre Australia*, Issue 6, August 2003. The article states "Not only did poor weather and competing tasks restrict the use of tactical air support during the RM assault, but Iraqi beach mining also hampered the landing of artillery and light armour. As such, the four warships poised offshore undertook a more vital than expected role, providing highly accurate and responsive indirect fire for 48 hours rather than the originally planned 24."

[252] Ibid.

superiority and deep strike. Enemy air defenses negatively impact danger close (near friendly troops) missions for troops in contact with the enemy.[253] Advanced air defense systems are specifically addressed in recent Defense transformation documents as posing a significant future threat.[254] The Defense Science Board was told that during Operation Iraqi Freedom TACAIR was generally unreliable and overly complex to use.[255] The cost to use of aviation to replace traditional NSFS systems can be significant. Table 11 indicates the combination of 155mm/60 caliber gun and Tomahawk (TLAM) missiles are about 20-30% the cost of Tactical Air if two Major Regional Conflicts (MRC) and low aircraft losses are assumed.[256]

Costs FY93 ($M)	Desert / Mountain	Heavily Defended	Total
Number of targets	235	285	520
Number of TACAIR sorties	595	849	1,444
Cost ($ millions)			
TACAIR - no attrition	$400	$461	$861
TACAIR - add for attrition	$160	$296	$456
TACAIR - Total	$560	$757	$1,317
155mm/60-cal + TLAM	$133	$153	$286

Table 11: CNA COEA Cost Comparison of Tactical Air and NSFS systems [257]

Alternative studies in Navy Force Structure: In February 2005, two studies submitted to Congress on potential future fleet architectures contained proposals for fire support warships.[258] The Center for Strategic and Budgetary Assessment called for a

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[253] Center for Naval Analysis, Memorandum for Major General H. W. Jenkins (N85) and Mr. Ronald Kiss (DASN (Ships)), 8-9. These two pages give detailed assessment of responsiveness, sortie generation rates, danger close targets, weather impacts and other factors that limit the ability of aviation assets to provide NSFS effects.

[254] Cebrowski, *Military Transformation: A Strategic Approach*, 18.

[255] *Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace*, 10.

[256] CNA, *NSFS COEA*, 115.

[257] Ibid., 115. It is not possible to inflate the costs cited to fiscal year 2007 levels due to multiple cost categories rolled into the overall costs provided. The low level losses were calculated in the early 1990's Tomahawk Baseline Improvement Program which assumed an 80% probability of kill. CNA was not comfortable with this analysis and believed it could be in error in either direction depending upon many factors that are difficult to predict.

[258] Congressional Research Service. *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* (Washington, DC: Library of Congress, 14 August 2006), CRS-36. Section 216 of the conference report (H.Rept. 108-354 of November 7, 2003) on the FY2004 defense authorization bill (H.R. 1588/P.L. 108-136 of November 24, 2003) required the Secretary of Defense to provide for two

modified LPD-17 (San Antonio class ship) hull for a low cost fire support ship carrying at least two 155mm Advanced Gun Systems.[259] The Office of Force Transformation (OFT) called for the construction of a 57,000 ton *missile and rocket ship* as part of a family of large warships constructed using commercial building practices.[260] This *weapons ship* concept would have 360 Vertical Launch System (VLS) cells and four trainable rocket launchers.[261] The call for these vessels indicates reputable organizations are aware of the shortfall in NSFS-capable vessels. The OFT weapons ship concept is similar in size to an *Iowa* class ship as both weigh about 57,000 tons.[262]

Previous Navy options for a capital surface warship: In the 1980s the Navy explored ten different options to modernize the *Iowa* class battleships for extended service.[263] The most costly proposal involved removing all three 16-inch gun turrets and adding 324 Tomahawk and 100 Standard Missiles and Aegis radars for a cost of $2 billion in 1989 dollars ($3.04 billion in FY2007 dollars). The Marines strongly opposed this option. The option ultimately approved included improvements such as 16-inch extended range ammunition, improved fire control system, counter battery target acquisition radars, and 96 VLS cells for Tomahawk missiles for a cost of $900 million per ship in 1989 dollars (inflated to $1.37 billion in FY2007).[264] The Navy canceled the

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independently performed studies on potential future fleet platform architectures for the Navy. The two studies were conducted by the Center for Naval Analyses (CNA) and the Office of Force Transformation (OFT, a part of the Office of the Secretary of Defense). A third independent study was conducted by the Center for Strategic and Budgetary Assessments (CSBA). CSBA conducted this study on its own initiative and made it available to congressional and other audiences in March 2005 as an alternative to the CNA and OFT studies.

[259] Ibid., CRS-40, CRS-43.

[260] Ibid., CRS-37-39.

[261] Stuart E. Johnson and Arthur K. Cebrowski, 57-60.

[262] William H. Garzke, Jr. and Robert O. Dulin, *Battleships: United States Battleships, 1935-1992.* (Annapolis, MD: Naval Institute Press, 1995), 260-261.

[263] Ibid., 255-264. Inflation formulas accessed 12 March 2007 at http://www.ncca.navy.mil/services/inflation.cfm.

[264] Ibid., 260-261. Inflation formulas accessed 12 March 2007 at http://www.ncca.navy.mil/services/inflation.cfm.

alteration when the USS *Iowa* and USS *New Jersey* were decommissioned in 1990.[265] Admiral Train indicates the Navy focused on modernizations of the Iowa class as opposed to new construction and outlines the reasoning in the following statement:

> There was no discussion to create a follow-on ship to the *Iowa's*. There were two reasons. First, their return to active service was to plug a hole in our existing capabilities. Four ships were enough to achieve that goal. Second, we anticipated they would serve until 2030 or 2040. We have aircraft carriers that have over 50 years in active service. The *Iowa* class ships are more ruggedly constructed than those ships and should last as long or longer in active service. We anticipated improvements similar to a Service Life Extension Program (SLEP) upgrade as made to aircraft carriers would extend the *Iowa* class ships service life well into the next century. This would also be similar to the longevity and utility considerations for the B-52 that have resulted in extending the life of these aircraft to over 50 years. With the long service life remaining in the *Iowa* class ships, no replacement ship class was proposed at the time we brought them back.[266]

It is significant that our improvements to and continued use of the B-52 was specifically cited as an achievement in the recent *Quadrennial Defense Review Report*.[267]

Survivability: In the previous NSFS studies, ship survivability appears to have been overlooked. A December 2006 report issued by Office of the Director, Operational Testing and Evaluation (ODOTE), an arm of the Defense Department was critical of the DDG-1000's survivability.[268] The concept of DDG-1000 as a minimally manned combat ship drew scrutiny. An Arleigh Burke-class destroyer has a crew of more than 300. The DDG-1000 will have fewer than 150 sailors.[269] The DDG-1000 will weigh 14,000 tons, and the DDG-51 weighs about 9,000 tons – twice as large with half the crew.[270] James O'Bryon, former Director of Live Fire Test and Evaluation, Office of the Secretary of Defense, addressed battleship survivability as follows:

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[265] Ibid., 264.
[266] Admiral Train Interview.
[267] "In its fifth decade of service, B-52s continue to provide long range strike capability to the joint force. The B-52 continues to be upgraded to provide new capabilities, including close air support…through the use of precision strike weapons." See *Quadrennial Defense Review Report*, 46.
[268] Andrew Scutro, "DOTE report criticizes LCS," *Navy Times*, 4 February 2007. Also see "Is New U.S. Destroyer unstable?"
[269] Ibid.
[270] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 21; U.S. Department of Defense Comptroller, *Program Acquisition Costs By Weapon System, Fiscal Year 2007* (Washington, DC: GPO, February 2006), 43.

> I have overseen a number of ship vulnerability programs over the years and, in my opinion, there is no tougher ship than the BB. While I believe that the DD (X)'s focus on hit avoidance is desirable, sometimes you cannot avoid the fight.[271]

The Navy has assessed *Iowa* Class ship vulnerability as recently as 1987 in a classified report with comments reasonably favorable to the survivability of these ships against modern ordnance.[272] Damage to these ships does not produce catastrophic failure. Vulnerability analysis indicated that systems would fail gradually as hits were sustained from modern ordnance.[273] Based upon unclassified information, this has not been the case with warships that have sustained hits since the Falklands War. See Appendix G for additional information on survivability.

Summary: Successful extended range gun projectile programs existed for 16-inch guns. Precision guidance reduces collateral damage effects yet the focus on limiting collateral damage should not overshadow the requirement for lethality. Major caliber guns are robust penetrators of hard targets. Air delivered ordnance, while very capable and currently the main source of joint fires cannot always be counted upon due to weather or competing mission priorities and becomes cost prohibitive in a high threat environment. A CSW equipped with major caliber guns and missiles provide capabilities such as 1) hard-hitting strike via major caliber guns; 2) visual impact to shape the operational environment through show of force; and 3) survivability. These capabilities will be critical to support airpower against the near-peer competitor or robust regional competitor with anti-access and anti-air capabilities in the future.

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[271] James F. O'Bryon, "Distortions about ships," *Washington Times*, 17 June, 2005. Accessed 6 March 2007 at http://www.washingtontimes.com/op-ed/20050616-100901-9551r.htm. DD(X) is now DDG-1000.

[272] U.S. Department of the Navy. *Ship Vulnerability Assessment for Missouri BB-63* (Bathesda, MD: Department David W. Taylor Naval Ship Research and Development Center, January 1987).

[273] Mark Cancian,. "Retaining Battleships" [information paper]. (Washington, DC: Office of Secretary of Defense, Program Analysis and Evaluation (GPP/FSAD), 20 November 1990), 8. The classified nature of this subject prohibits greater specificity.

Chapter 6: Modeling a Robust NSFS Capability

The Army we're fighting is different from the Army we gamed against –
Lieutenant General William Wallace
Commander, U.S Army V Corps, Iraq, 2003[274]

Modeling can't perfectly predict the future, but it is a valuable tool to gain insight, which is why the Department of Defense requires a robust analytic process such as a simulation to test concepts and ideas within the Joint Requirements process.[275] Not one of the analytic studies conducted since 2000 appears to have included a major caliber gun system, or a large warship with major and minor caliber guns supported with significant magazine capacity. To assess the potential impact of such a platform in a current and approved simulation scenario, the Fires Battle Lab at the Army Fires Center of Excellence (Fort Sill, Oklahoma) and Tec-masters, Inc. offered to support this study using the FireSim XXI model. See Appendix F for more information.

Simulation Goal: The simulation was intended to assess the macro impact to an existing simulation results (hereafter referred to as the "archive simulation") against a new simulation that replaced two DDG-51 ships with two Capital Surface Warships (hereafter referred to as the "CSW simulation"). The layout of the Capital Surface Warship (CSW) is similar to an *Iowa* class ship with the following capabilities.

1) Extended range major caliber projectiles carrying brilliant munitions such as Search and Destroy Anti-armor Munition (SADARM).
2) Precision guided (course correcting fuse) major caliber unitary munitions.
3) Long range precision guided minor caliber munitions supported by large magazine capacity.
3) Short range minor caliber munitions supported by large magazine capacity.

The simulation scenario background history: The simulation uses an Operational Maneuver from the Sea (OMFTS) scenario initially developed by the Marine Corps Combat Development Command (MCCDC) for use in the Advanced Amphibious

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[274] General Tony Zinni. *The Battle for Peace*. (NY: Palgrave Macmillan, 2006), 67
[275] *Joint Capabilities Integration and Development System*, 2.

Assault Vehicle (AAAV) V-22 analysis. It was implemented in FireSim XXI for the Joint Army and Marine Corps 155mm Lightweight Howitzer COEA beginning in 1994. The Joint Staff J-8 recently used this scenario in the 2004 "Joint Forcible Entry Operations Study."[276] The scenario was screened and approved by Joint Chiefs of Staff, J-8, Director for Force Structure, Resource, and Assessment, as an appropriate vehicle for Joint analyses.[277] The scenario was updated several times and will support the upcoming Guided Forward Fired Miniature Munitions Analysis of Alternatives.[278]

Scenario selection criteria: The Fires Battle Lab and Tec-masters suggested the OMFTS scenario since it was readily available within the FireSim XXI architecture, and will be used in a new simulation requirement. The OMFTS data structure contained the 5-inch Extended Range Munition for DDG-51 ships and the 155mm Long Range Attack Projectile (LRLAP) for the DDG-1000 ships. The one modification required was the addition of the Capital Surface Warship and its suite of weapons. The Artillery Team of the US Army Materiel Systems Analysis Activity at Aberdeen Proving Ground ensured lethality data was correct for the proposed munitions.[279]

Ship	Ammunition Type	Rounds per Ship	Simulation Range (meters)
CSW	5-inch ERM Point Detonating Fuze (ERM-HE PD)	500	101,000
	5-inch ERM Variable Time Fuze (ERM-HE VT)	500	101,000
	5-inch Mk-64 Point Detonating Fuze (Mk-64 HE PD)	1,750	20,917
	5-inch Mk-64 Variable Time Fuze (Mk-64-HE VT)	1,750	20,917
	16-inch EX-148 Variable Time Fuze (EX148-HE VT)	325	62,000
	16-inch Mk-13 Variable Time Fuze (Mk13-HE VT)	325	38,000
	16-inch Mk-13 SADARM	50	38,000
	16-inch Scramjet Variable Time Fuze	350	740,000
	16-inch Scramjet SADARM	325	740,000
DDG-51	5-inch ERM Variable Time Fuze (ERM-VT)	350	101,000
DDG-1000	155mm Long Range Land Attack Projectiles	650	140,000

Table 12: Munition types by single ship employed in the OMFTS scenario.[280]

[276] Interview, Sue Quensel and Alan Zimm, 21 and 22 March 2007. Study concluded 8 November 2004.
[277] Interview, Alan Zimm, 22 March 20-07
[278] Ibid.
[279] Interviews, Kathy Luft and Willam Clay, 13, 14, 19 December 2006, 11 January 2007. Kathy Luft and her team provided an invaluable service to this simulation by ensuring the lethality data was realistic.
[280] The term HE is "high explosive," PD is "Point Detonating" fuse, and VT is "Variable Time" fuse.

The two DDG-51 ships in the archived simulation were replaced by two surrogate Capital Surface Warships (CSW) for the CSW simulation. The CSW holds a total of 1,375 rounds of major caliber munitions. CSW minor (5-inch) caliber munitions total is 3,500 rounds, which include 1,000 Extended Range Munitions (ERM). 16-inch munitions are a valid surrogate major caliber weapon given previously examined or tested projectiles as outlined in Chapter 3 and 5. The brilliant munition SADARM was chosen for application to 16-inch projectiles as it was already in the OMFTS scenario's munitions data set and 16-inch projectiles could carry SADARM. The Mk-13 projectile was estimated to hold approximately twelve SADARM munitions.[281] The scramjet was initially estimated to hold between six to nine SADARM. It was played with 9 to provide the EX-148 SADARM capability.[282] This was due to Tech-Masters lack of time to load an additional munition. The scramjet was employed as an example type for a very long-range major caliber munition launched either by an electromagnetic rail gun or advanced propellant and a sabot type accelerator. All munitions except the 5-inch Mk-64 were modeled with precision guidance package's course correcting fuse.

Overview of the Scenario:[283] The scenario is set in the year 2010. North Korea (Orange) has invaded South Korea. They have initially pushed south of the DMZ approximately 60-90 kilometers. The Orange offensive was held at this point. By day 60 of the war, Orange is preparing to renew the offensive along the east coast. They are massing approximately 200 battalions for a push on the port cities of Pusan and Pohang.

To preempt this anticipated attack, Allied forces (Blue) are planning to employ OMFTS doctrine to cut off and isolate the attackers. A landing is planned behind enemy

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281 CNA, *NSFS COEA*, 57-59.
282 Ibid.
283 All material in this section provided by Sue Quensel, 20 March 2007.

lines to preempt Orange's attack, isolate forward elements, destroy the enemy maneuver force and recapture key terrain.

The terrain in this area is important. Beginning on the east coast, the ground is flat and trafficable for approximately 15 kilometers inland -- and then becomes very rough. The rest of the battle area is mountainous and broken. There are only a few roads of dubious quality inland; most of these converge on the small town of Inje. If the Blue Forces can hold the coastal road network and the roads in the vicinity of Inje, the Orange maneuver force will be isolated. Consequently, the mission of the Blue amphibious force is to make a forced entry landing, take and defend the coastal strip, and press inland to take and defend the road network around Inje. Additional scenario information to include maps is provided in Appendix F.

Analytic shortfalls: The simulation was provided at no charge by Tec-masters with work conducted between scheduled projects. There was very limited time to build specific data reports and to conduct quality control and correction of several apparent anomalies. The CSW simulation was given a few preliminary runs to confirm the accuracy of the data structure and then processed twice with the results averaged as opposed to the twenty plus iterations that created the original archived simulation data. Several anomalies exist in the CSW simulation. The specific lethality of major caliber projectiles and how well the 50-meter Circular Error Probable (CEP) Course Correcting Fuse was applied requires additional analysis. Upon reviewing the data output, the one hundred pound 5-inch Extended Range Munition (ERM) appeared slightly more lethal than a standard 1,900-pound 16-inch high explosive projectile. Though ERM was more accurate, both were precision guided and the lethal area of the 16-inch projectile was much larger than the CEP error. There was no time to analyze this similar level of lethality for two very dissimilar projectiles to determine the reason for this obvious

lethality inconsistency. Including one B-52 sortie, there were 80 Tactical Air Support sorties per day or slightly more than one dedicated aircraft carrier. There was no adverse weather, which is unlikely as adverse weather is common in the simulation's location. There was no enemy air-defense threat or defensive air based on the assumption the earlier missions in the scenario would eliminate these threats. The J-8 approved this overplayed air approach as other gaps besides air were under analysis.[284] It was a perfect and unlikely situation for TACAIR, even with the situation given as at least a 30% degradation in TACAIR performance could be expected.[285] In the archive simulation, air was preset for specific kills. In the CSW simulation, it was adjusted to react to calls for fire. Other than this change, there was no ability to make the air simulation more realistic.[286] It is expected that changing aviation rules to increase realism in the archive simulation would reduce aviation kills. Also of note is a lack of missiles or rockets in the scenario. This should be reviewed for doctrinal accuracy. Further, there were no field fortifications or fixed hard targets played as Orange had offensively penetrated Blue territory. While correct, this did not enable an assessment of the penetration power of major caliber guns. Lastly, there was no ability to assess the firing systems ability to meet the 2.5-minute or 10-minute response times from call for fire to ordnance on target.

The results in brief: The simulation showed a significant improvement in NSFS capability with the substitution of two CSWs for two DDG-51s. The loss exchange ratio shows an approximate increase of 35% in favor of Blue forces against the archived scenario. Based upon the results of the initial runs, it is reasonable to assume a 15-25% improvement in the loss exchange ratio achieved. This assumes proper correction and

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[284] Interview, Alan Zimm, 22 March 2007.
[285] Interview, Sue Quensel, 20 March 2007.
[286] Ibid.

tuning to validate the data is performing correctly and the commander's guidance in AFATDS and ammunition priorities are correct for the new balance of capabilities.[287] Orange losses grew significantly, and Blue losses were slightly reduced due to the added fires of two CSWs.

Simulation	Orange Losses	Blue Losses	Loss Exchange Ratio
Archive	3,208	685	4.68
CWS	4,196	667	6.29
Loss delta	988	-18	1.61

Table 13: Loss Exchange Ratio.

CSW vs Archive Simulation	Range Bands (Kilometers)			
	0 - 39	40 - 99	100 +	Total
Delta of Total Kills	485	448	55	988
Delta of Veh Kills	148	84	15	247
% Delta of Total Kills	120%	158%	600%	131%
% Delta of Veh only Kills	163%	201%	850%	177%

Table 14: Kill comparison between simulations.

Table 14 shows a significant increase in kills over the archive simulation. These increases include mortars, artillery, anti-air systems, armored personnel carriers, and tanks. Overall there is a 130% increase in all kills in the CSW simulation. Increases by target category are shown in Table 15 below.

Target Category	Increase	CSW Simulation	Archive Simulation
Mortars	277.8%	25	9
Artillery	272.2%	98	36
Anti-Air Artillery	228.6%	16	7
Armored Pers. Carriers	200.0%	28	14
Tanks	180.0%	72	40
Anti-Tank Gun	175.0%	7	4
Trucks and Vans	157.1%	253	161
Multiple Launch Rocket	137.5%	66	48
Personnel	125.6%	3,630	2,889
Radar	100.0%	1	0
Total	***130.8%***	***4,196***	***3,208***

Table 15: Percent Increase in Kills by Target Category.

The table below shows the introduction of the CSW greatly changes the distribution of kills between major weapons platforms and systems.

[287] Interview, Alan Zimm, 25 March 2007.

Platform or System	Simulation	Total Kills	Percent Kills by Simulation
CSW	CSW	1,739	41.4%
DDG-51	Archive	146	4.6%
DDG-1000	CSW	468	11.2%
DDG-1000	Archive	596	18.6%
Aviation	CSW	1,674	39.9%
Aviation	Archive	1,809	56.4%
Artillery	CSW	273	6.5%
Artillery	Archive	592	18.5%

Table 16: Kill Comparison between systems and simulations.

The percentages above are based upon a total of 4,196 kills in the CSW simulation and 3,208 kills in the archive simulation. The DDG-51 accounted for less than 5% of the kills in the archive simulation. Relative value of DDG-51 to CSW is between eleven and twenty to one. This indicates the DDG-51 class ship with ERM munitions has a relative effectiveness of 5-8% compared to a CSW depending upon type of target (hard or soft). Relative kill value of DDG-1000 to CSW is between three (vehicles) and eight (personnel) to one. When the CSW replaces DDG-51, it garners 41% of the kills overall as opposed to 4.6%, and reduces the aviation and artillery kill percentages by over 10% from the archive simulation. The impact of the CSW's volume fire capability and lethality is apparent in the next two tables.

Platform or System	Missions or Rounds Fired by Weapon Type	Range Bands (Kilometers)			
		0 - 39	40 - 99	100 +	Total
CSW (2 ships)	5-inch Missions	184	168	31	383
	5-inch Rounds fired	5,403	1,450	485	7,338
	Major Caliber Missions	187	141	25	353
	Major Caliber Rounds fired	1,218	1,184	290	2,692
DDG-1000 (2 ships)	LRLAP Missions Fired	21	275	9	305
	LRLAP Rounds Fired	51	1,016	35	1,102
Artillery	Missions Fired	69			69
	Rounds Fired	1,468			1,468
USMC Expeditionary Mortar (EFSS)	Missions Fired	84			84
	Rounds Fired	1,373			1,373
Fixed Wing 80 sorties	Mission calls	448	27		475
	Ordnance Dropped	1,729	75		1,804
Mortars	Missions Fired	139			139
	Rounds Fired	2,895			2,895

Table 17: CSW Simulation Missions and Rounds Fired

Both the 5-inch ERM and 155mm LRLAP munitions are fired in significant numbers at ranges in excess of 40,000 meters (21.7 nautical miles). The shorter range conventional 5-inch shells were fired at ranges less than 40 kilometers and averaged 38 rounds per mission with 3-8% effectiveness per round and 134% to 325% average effectiveness per mission indicating a large number of rounds were fired and the cumulative effect was substantial. Effectiveness is the percent of kills per mission. This indicates the continued utility of volume fires enabled by significant magazine capacity.

Platform or System	Type Ordanace and Type Kill	Range Bands (Kilometers)			
		0 - 39	40 - 99	100 +	Total
CSW (2 ships)	5-inch Total Kills	440	316	24	780
	5-inch Vehicle Kills	24	35	3	62
	Major Caliber Total Kills	600	323	36	959
	Major Caliber Vehicle Kills	155	72	12	239
DDG-1000 (2 ships)	LRLAP Total Kills	35	427	6	468
	LRLAP Vehicle Kills	2	33	2	37
Artillery	Total Kills	273			273
	Vehicle Kills	29			29
USMC Expeditionary Mortar (EFSS)	Total Kills	13			13
	Vehicle Kills	0			0
Fixed Wing 80 sorties	Total Kills	1521	27		1,548
	Vehicle Kills	172	75		247
Mortars	Total Kills	29			29
	Vehicle Kills	0			0

Table 18: CSW Simulation Total Kills by major weapon category.

The high number of vehicle kills achieved by the major caliber guns is demonstrated in Table 16. Major caliber guns and aviation accounted for the largest vehicle kills by weapon category. The CSW with both major and minor caliber guns killed more vehicles than any other weapons system. The CSW killed 88% of the artillery, 68% of the mortars, and 61% of the multiple launch rocket systems. The number of artillery systems killed doubled, with the CSW making 77% of the kills. If a consistent trend, this is extremely significant to the ground force commander. This is congruent with past combat operations.[288] The CSW also killed 24% of the tanks and

[288] Riley, 199.

25% of the armored personnel carriers. And while in both scenarios the DDG-1000 and the DDG-51 did not kill any air defense artillery, the CSW killed three systems.

The DDG-1000's Advanced Gun System and LRLAP projectile demonstrated a high overall level of effectiveness with a 42% overall kill ratio for rounds fired. This is likely attributable to the precision guidance of the munition. ERMs precision guidance provided effectiveness similar to field artillery (18-21%) but firing an average of 11 to 15 rounds per mission as opposed to the field artillery's 20 rounds per mission average. The CSW garnered significant ERM kills due to greater magazine capacity, something current and programmed ships cannot replicate (Chapters 3 and 5). At ranges beyond 100 kilometers, the LRLAP and Scramjet major caliber projectiles achieved approximately the same percentage of kills to rounds fired for personnel and vehicle targets. The major caliber round did fire upon and kill targets about 30 kilometers farther than LRLAP, but nowhere approaching the full range potential of the munition. This should be examined more closely. Neither the ERM nor LRLAP could come close to the major caliber SADARM projectiles for effectiveness. The very long-range projectile demonstrated a 70% kill ratio, and the Mk-13 SADARM demonstrated a 207% kill ratio. Major caliber guns are extremely potent munitions dispensers.

Summary: The replacement of two DDG-51 ships with two CSW in the OMFTS scenario demonstrates a 30% to 70% increase (based on target type) in combat power placed at the hands of the Joint Force Commander. CSW delivers much greater firepower than either DDG-51 or DDG-1000. The two CSW garners kills greater than 80 aircraft sorties which include a B-52. While the CSW simulation has several significant areas that require additional analysis and evaluation, the overall results show a 30% to 35% increase in effectiveness (increased kills and loss exchange ratio) over the archived simulation. If hard battlefield targets were included in the scenario, it is reasonable to

conclude the effectiveness of the CSW with major caliber guns would be even greater than either DDG-1000 or aviation. This simulation indicates the need to further explore the capability potential of major caliber guns to deliver significant firepower at very long ranges. Additionally, minor caliber guns with extended range munitions on large platforms with significant magazine capacity clearly merits further analysis. Likely the most significant finding to arise from a comparison of the archive simulation and the CSW simulation is the potential impact to friendly operations if U.S. airpower is somehow mitigated by the enemy. If a significant enemy anti-air capability were to inhibit U.S. air operations against enemy ground forces in the archive scenario, there is no other U.S. capability available to make up the shortfall in lethality. In the CSW simulation, both aviation and the CSW demonstrated a similar lethality capability (see Table 16). This indicates the CSW provides a level of lethality that is not available in the air centric archive scenario in the event of a disruption of U.S. air capability. Many of the points brought out in the simulation results, such as volume fires, effectiveness (lethality), and the ability to defeat a competent regional competitor are part of the risk evaluation criteria in the recommendations in Chapter 8.

Chapter 7: Cost Considerations for Increased Capability

The Joint Requirements process is intended to address overall cost and programming impacts of major weapons systems.[289] However, the efforts to date for NSFS do not indicate a holistic assessment of capital surface warship costs in relation to the cost of other platforms, such as the aircraft carrier, that provide comparable fire support muscle. Assuming static defense budgets in the future, sustaining more than eleven carriers in the fleet is not likely without considerable reductions elsewhere in the fleet or DoD budget.[290]

During Iraqi Freedom and Enduring Freedom, a very significant portion of the U.S. carrier fleet has been used. Five aircraft carriers supported Operation Enduring Freedom and an equal number were directly engaged in Iraqi Freedom.[291] If both operations occurred simultaneously, the U.S. would have been short carriers. At any time, one to three carriers are in maintenance or otherwise unavailable. This illustrates the constraints on the Navy's goal of being able to surge more than eight carriers within ninety days.[292] During a regional contingency, three to four aircraft carriers at most remain available for other operations. Its force-sizing construct calls for the United States to maintain the ability to engage two nearly simultaneous conflicts, swiftly defeating one,

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[289] U.S. Joint Chiefs of Staff, *Chairman of the Joint Chiefs of Staff Instruction 5123.01B. Charter of the Joint Requirements Oversight Council*, A-6.

[290] Sandra I. Erwin, "A Navy With Fewer Aircraft Carriers No Longer Unthinkable." *National Defense Magazine*, March 2007. Naval historian Normal Polmar states "The affordability of carriers – that's what's going to sink them."

[291] Williamson Murray, and Robert H. Scales, *The Iraq War* (Cambridge, MA: The Belknap Press of Harvard University Press, 2003), X, XI, 7, 15-21, 42-45, 52-53, 61-62, 71-72; Benjamin S Lambeth,. *American Carrier Air Power at the Dawn of a New Century* (Arlington, VA: The RAND Corporation, 2003), iii, x, xiii, xiv. RAND states that six carriers were used in Iraqi Freedom and six in Enduring Freedom (Afghanistan). The Navy's new force construct is to have six carriers plus two ready to deploy at any one time. Three aircraft carriers were on station out of a total of five carriers deployed supporting Operation Enduring Freedom. Five aircraft carriers with three more readily available supported Operation Iraqi Freedom (OIF). The Navy's goal to surge a total of eight carriers indicates that operations over Iraq precluded support to any other major regional contingency during the window of Iraq's major combat operations. The Navy intends to change its policies on aircraft carrier presence missions to ensure it can source "six plus two" aircraft carriers to support a major contingency.

[292] Lambeth., XIV, 61.

win decisively in the other.[293] Additional information on carrier employment is available in the classified Global Naval Force Presence Policy.

In 2001, Afghanistan lacked a modern, well-equipped and well-led military, and Iraq was not much better. It is logical to assume the forces required to defeat these regimes were more appropriately sized for a low-end operation than a high-end "win decisive" against a formidable regional competitor with anti-access capabilities. A simultaneous "win decisively" in Korea and a "swiftly defeat" the adversary in the Taiwan Straits while simultaneously maintaining GWOT commitments would require more naval forces than applied to either Mid-East conflict. Add a mildly degraded air environment, and the U.S. may find itself in a situation where it cannot provide the required fire support from air alone.[294] The Navy's intent to maintain aircraft over the target area continuously to meet on-call fire support requirements cannot be guaranteed in a hostile air environment.[295] This is likely problematic against a near-peer competitor.

The Navy's 30-year shipbuilding report, as summarized in the following chart, shows a reduction to ten carriers in 2013 and 2014, and a return to twelve aircraft carriers by 2019.[296] Fiscal pressures likely cap the force at eleven carriers.[297]

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[293] *Quadrennial Defense Review Report*, 38. Winning decisively entails removing the hostile regime, destroying its military capacity and set conditions for the transition to, or the restoration of, civil society.

[294] Lambeth, *American Carrier Air Power at the Dawn of a New Century*, 45. The air environment over Iraq was extremely permissive. The Iraqis did not use anti-air radars during Iraqi Freedom. To assume the same of North Korea or during a fight for Taiwan is inappropriate.

[295] Ibid., xi, xiv, 49, 50, 55, 63, 79. Naval air maintained 24 hour presence over the battle area during much of Iraqi Freedom. Lack of enemy air or anti-air threat enabled the Navy to provide near 24 hour presence during Enduring Freedom (Afghanistan).

[296] U.S. Department of the Navy., *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2007* (Washington, DC: Department of the Navy, 2006), 6. Significantly, the number of surface warships drops from a high of 113 in FY11 to 91 in FY16 to a low of 73 in FY36. No capital surface warship is contemplated.

[297] Sandra I. Erwin, "A Navy With Fewer Aircraft Carriers No Longer Unthinkable," *National Defense Magazine*, March 2007. The article states, "The Navy has eleven carriers but it may have to get by with fewer. They cost nearly $10 billion apiece to build, and billions more to keep afloat. These expenses are becoming harder to justify when the Navy is trying to grow from 280 to 313 ships during the next 30 years, with an annual shipbuilding budget of about $13 billion." The FY 2007 Navy 30 year shipbuilding plan does not align with this statement.

FY2007 to FY2012	11 aircraft carriers
FY2013 to FY2014	10 aircraft carriers
FY2015 to FY2018	11 aircraft carriers
FY2019 to FY2036	12 aircraft carriers

Table 19: Aircraft Carrier strength identified in 2007 Thirty-Year Shipbuilding Plan. [298]

Chapter 1 identified the near-peer competitor's arrival being sometime after 2015, most likely in the 2020 to 2025 time period. This provides the U.S. approximately twelve to 18 years to increase capabilities such as NSFS for littoral operations. Within that time period, the Navy's aircraft carrier strength will increase to twelve, a net gain of one from the present. Indications are that more than one additional aircraft carrier is required to meet the future near-peer competitor.[299] Instead of more aircraft carriers, another, less costly way to gain a significant increase in littoral firepower is a Capital Surface Warship (CSW). Ship construction, aircraft procurement, and ordnance procurement costs are addressed with limited detail in Appendix E. Design and construction time lines as outlined in Appendix E for a major warship are within the 18-year window of time before the emergence of a near-peer competitor.

Ship Type	Cost ($B)	Total Ships	Total Cost	% of 4 CSW
CVN-21 ship only	$13.7	5	$61.7	154.1%
CVN-21 w/air wing	$19.0	5	$85.5	213.8%
DDG-1000	$3.4	24	$73.4	183.6%
CSW	$10.0	4	$40.0	N/A

Table 20: Procurement cost examples.[300]

Given the heavy emphasis placed upon air-delivered weapons to support the NSFS mission, the cost analyst must consider the basic backbone of the aircraft delivery

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[298] *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2007*, 6

[299] China is identified both as the most likely near-peer threat and as growing in military capability. See *Quadrennial Defense Review Report*, 29.; "The sheer scale of a peer changes the character of the fight. As a result, developing the capabilities identified in this version of the concept will not provide all of the capabilities needed to address either Case Two or Case Three." See *JOC Major Combat Operations (*2004), 3.

[300] *Program Acquisition Costs By Weapon System, Fiscal Year 2008*, 48. Cost for DDG-1000 is based upon FY07 appropriation and the FY08 request as reflected in the document and then divided for two ships. Five new CVN-21 ships is based upon the 30-year construction plan. See *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2007*, 6; The acquisition cost of an air wing is detailed in Table A9; The estimate for the CSW procurement cost is described in Appendix E.

of weapons - the aircraft carrier and its air wing. The first bomb is not dropped until the annual operations and support bill is paid for both the ship and the air wing. It is the operating costs that are most often cited by the Navy as excessive for a battleship and therefore by extension a CSW.[301] Assume that operations and support costs of a future CSW would be similar to historic operations and support costs for an *Iowa* class ship.

FY07 Constant Dollars ($M)	By Year Averages		
Ship and Data Class	FY84-87	FY88-90	FY91-94
Average Number of Ships	2.0	3.3	1.0
Average Ship Expenditure	$83.8	$83.8	$112.2

Table 21: Historic operations and support expenditures for *Iowa* class ships [302]

The expenditures for these ships demonstrate consistency across the seven plus years in Table 21. It is reasonable to assume a CSW compared to an *Iowa* class ship: (1) would have a smaller crew and thus a similar or slightly reduced personnel cost after inflation is considered; (2) would be more economical under steaming conditions; (3) would have state of the art systems with lower maintenance costs; and (4) would take advantage of modern weapons and steels to produce a harder, more resilient ship with guns of greater lethality, longevity and safety. Given assumptions 1-3 above to account for inflation, it is reasonable to apply historic battleship operating costs as a reasonable surrogate for the annual O&S cost of a future Capital Surface Warship.

All of the fire support munitions considered in the ICD analysis was air-delivered, missile-delivered, or gun-delivered.[303] Most of the air delivered munitions will come

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[301] *Issues Related to Navy Battleships*, 5; Vice Admiral Stanley Arthur, "Desert Storm at Sea." *U.S. Naval Institute Proceedings*, Naval Review 1991, 82.

[302] Financial expenditure data was provided from Navy Visibility and Management of Operating and Supporting Costs (VAMOSC) accessed at http://www.navyvamosc.com/ . Virginie Collin-Banerji, Julian Kwan and Frank Mossburg of IBM Business Consulting provided assistance with confirmation of data accuracy and interpretation. These costs cover personnel, maintenance and underway steaming costs. The data provided is generally accurate, with most anomalies addressed in the documentation provided at the VAMOSC website. The high average cost for BB's in the FY91-94 time period is due to a $34 million increase for 16-inch munitions. These ammunition costs were not present in the earlier costs and likely include ammunition movement and storage costs upon decommissioning of the last battleships in 1990-91 time period. Cost accounting categories include personnel (officers, warrant officers and enlisted), engineering and technical services, fuel, maintenance in public and private shipyards, etc.

[303] *Joint Fires in Support of Expeditionary Operations in the Littorals ICD FNA*, slide 3, 6.

from planes flown from the decks of aircraft carriers. The chart below shows a breakout of the operations and support costs for a CVN-68 class ship and its air wing.

FY07 Constant Dollars ($M)						
Ship and Data Class	FY84-87	FY88-90	FY91-94	FY95-98	FY99-02	FY03-05
Number of Ships	3	4	6	7	8	9
Ave Cost of Air Wing		$357.7	$312.7	$272.3	$332.2	$329.8
Average Ship Cost	$299.0	$193.2	$241.1	$248.6	$298.9	$354.6
CVN-68 Total cost		$550.9	$553.8	$520.9	$631.1	$684.4

Table 22: Average annual O&S cost for a CVN-68 class ship and a typical air wing.[304]

Aircraft carrier and aircraft costs are relevant as air delivered ordnance was considered heavily in the development of the Joint Fires in Littoral Operations ICD. Crew size is also an important consideration and is shown in Table 23.

Ship	84-87	88-90	91-94	95-98	99-02	03-05	Percent of CVN
CVN-68	5,500	5,500	5,500	5,500	5,500	5,500	100.0%
BB-61	1,460	1,388	1,390	1,390	1,390	1,390	25.3%
CG-47	354	359	374	370	360	383	7.0%
DDG-51			328	313	305	338	6.1%
DDG-1000						142	2.6%
Wpns Ship						500	9.1%

Table 23: Average crew sizes.[305]

[304] Financial expenditure data was provided from Navy Visibility and Management of Operating and Supporting Costs (VAMOSC) accessed at http://www.navyvamosc.com/. The data provided is generally accurate, with most anomalies addressed in the documentation provided at the VAMOSC website. The cost of the carrier without aircraft has risen steadily from $299m annual average from 1984-48 to $354m annual in FY03-05. The air wing has also remained relatively steady from $357m in FY88-90 to $329m in FY03-05. The carrier air wing was reduced in aircraft size from approximately 90 aircraft in FY91 to about 56 aircraft in FY05. The fact the cost stayed relatively constant is a testament to the rising cost of operating aircraft. The only true cost measure of an Aircraft Carrier is the ship plus the air wing. The air wing costs were developed using an average air wing approach. Costs were provided from VAMOSC by aircraft type and total number of that type of aircraft in the fleet at the end of the fiscal year in question. This aggregate cost was then divided by the average of the total number of aircraft in inventory at the beginning and end of a fiscal year to develop an average a per plane cost. This in turn was multiplied by the number of aircraft assigned in the average air wing. This is a ballpark cost that includes maintenance personnel and pilot costs but does not account for regional or other cost variances. Ship costs do not include any nuclear operations or overhaul costs. Those costs contained in other programs that are not reported in VAMOSC. The extent and scope of these costs is unknown and could represent a significant shortfall in the true O&S cost of the nuclear aircraft carrier. Data to calculate the air wing cost for FY84-87 was not available in VAMOSC.

[305] The DDG-1000 and Wpns Ship concepts are included in the FY03-05 Average for comparison purposes only. BB-61, CG-47 and DDG-51 crew sizes were obtained from VAMOSC. DDG-1000 crew size accessed 25 March 2007 at http://www.dau.mil/conferences/presentations/2006_PEO_SYSCOM/tue/A1-Second.pdf; Average crew plus air wing size for CVN was accessed 25 March 2007 at http://www.navy.com/about/shipsequipment/aircraftcarriers/decks/ ; Crew size for hypothetical weapons ship, see Johnson and Cebrowski, 57.

Comparisons of the O&S costs of the four ship types that can provide naval fires, including the aircraft carrier are outlined in the following chart.[306]

FY07 Constant Dollars ($M)						
Ship and Data Class	FY84-87	FY88-90	FY91-94	FY95-98	FY99-02	FY03-05
CVN-68 Average Ship and Airwing Cost		$550.9	$553.8	$520.9	$631.1	$684.4
BB-61 Average Ship Cost	$83.8	$83.8	$112.2	*$93.3*	*$93.3*	*$93.3*
CG-47 Average Ship Cost	$33.0	$32.3	$40.0	$37.9	$43.4	$44.0
DDG-51 Average Ship Cost			$27.2	$30.3	$32.3	$34.9

Table 24: Historic Operations and Support Expenditures for Ships by Class – FY84 to FY05 [307]

The cost in Table 24 shows considerable and expected differences in operations and support costs for the various ship platforms. The largest costs are for the CVN-68 nuclear aircraft carrier. The cost for the *Iowa* (BB-61) is much closer to the cost of a Ticonderoga cruiser (CG-47) or Arleigh Burke destroyer (DDG-51) than an aircraft carrier (CVN-68). The costs of the aircraft carrier and its air wing do not include considerations such as the cost of aircraft losses and aborted missions, which increase wartime costs. Another consideration is additional battleship investments during the late 1980s were cited as an alterative to propagating a NSFS capability throughout the fleet:

> The volume and range of NSFS provided by the BB is useful only in support of major amphibious operations. Such operations would commit a large fraction of the Navy's amphibious shipping and a small fraction of its surface combatants. Using the BBs as specialist fire support ships in these circumstances when viewed from the force level is

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[306] The new SSGN-726 conversions are not included. SSGN-726 average FY03-05 annual O&S cost is $53m in FY07 constant dollars; however, those costs are very inconsistent between individual years, rising from $21m to $96m per year. SSGN716 is not included due to these inconsistencies and their only naval fires weapon is the Tomahawk missile, which General Hagee stated specifically in April 2006 is not a tactical fires weapon. See *Report on Naval Surface Fire Support*, Commandant of the Marine Corps Attachment, 3. Grey boxes represent either no cost or inflated estimates based upon prior year costs.

[307] Financial expenditure data was provided from Navy Visibility and Management of Operating and Supporting Costs (VAMOSC) accessed at http://www.navyvamosc.com/. Costs are not provided for the BB-61 class post FY1992 as the ship of that class was decommissioned that year. The 1991 for BB-61 class cost increased by $34m due to the addition of ammunition costs. This is inconsistent with other ship comparisons as not one of the DDG-51, CG-47 or SSN's include the cost of torpedoes, missiles or gun munitions. However, to account for any unforeseen costs of a future capital surface warship, the average cost straight lined to create the FY95 to FY05 projections included the $34m in 16-inch ammunition costs from FY91. This was done as a hedge against future unknown costs. The only munitions costs that appear to be included for all the other ships are training munitions and munitions handling, and the costs are under a million dollars per year in the FY2004 and FY2005 timeframes.

> very economical because an expensive, rarely used but vitally needed capability does not have to be propagated through the fleet.[308]

The volume and weight of ordnance that a capital surface warship and an aircraft carrier can deliver is significant. This becomes clear in Table 25.

Type of Projectile/Bomb	Weight	# shells 1 hour	Total Weight	Eqv Factor	# shells 1 hr Surge	Total Weight	One Day # Shells	One Day Weight
Capital Surface Warhip (CSW) Surogate								
16-inch Mk-13 HE	1,900	540	1,026,000	3.2	810	1,539,000	1,250	2,375,000
16-inch EX-148	950	540	513,000	1.6	810	769,500	1,250	1,187,500
16-inch/280mm sabot	600	540	324,000	**1.0**	810	486,000	1,250	750,000
16-inch - mix 1/3 of each type	1,150	540	621,000	1.9	810	931,500	1,250	1,437,500
5-inch ERM "like" munition	110	360	39,600	0.1	1,800	198,000	4,000	440,000
DDG-1000 / DDG-51								
155mm AGS	150	480	72,000	0.2	600	90,000	600	90,000
5-inch ERM	110	240	26,400	0.1	240	26,400	300	33,000
Single CVN full strike:								
F/A-18 (40 aircraft)	480,000	480	480,000	1.5	480	480,000	960	960,000
Two B-52								
B-52 with 180 Small Diameter Bombs	135,000	360	135,000	0.4	360	135,000	360	135,000
B-52 with 18 JDAM	72,000	36	72,000	0.2	36	72,000	36	72,000
B-52 with theoretic maximum weight load	144,000	72	144,000	0.4	72	144,000	72	144,000

Table 25: Comparison of ordnance delivery potential by weight (pounds).[309]

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[308] James S. O'Brasky, Comments on "The Improved 16-inch Gun Weapon System." *Naval Engineers Journal* (Vol. 100, July 1988), 151. The statement that the firepower of a battleship's 16-inch guns are only useful in an amphibious assault overlooks the very real value of gun strikes at ranges of 20 to 400 miles. These strikes could clearly be tactical, operational or strategic in nature and not be tied to an amphibious operation.

[309] Ordnance data for the FA-18 and B-52 was obtained from http://www.globalsecurity.org/ on 20 December 2006. Separate web pages are provided for each type of aircraft and type of bomb available. Calculations are simplistic and meant only to demonstrate an order of magnitude comparison. The FA-18-E/F calculations are based upon an assumption of 40 aircraft on a CVN. Each aircraft has six bomb hard points capable of carrying 2000 pounds for a total load of 12,000 pounds for 480,000 pounds. This is the theoretical maximum full sortie capability. Two sorties of the entire wing is the single day maximum. The DDG-51 has one 5-inch Extended Range Munition (ERM) capable gun and the DDG-1000 has two 155mm Advanced Gun Systems (AGS). The magazine capacity is 300 for ERM and 600 for AGS. Shell weights are averages only. The Equivalency Factor holds the 16-inch/280mm sabot as "1" with the total weight of each of the other 1 hour maximums factored against the weight for the 16-inch/280mm sabot. The 400 nautical mile scramjet projectile can surrogate the ordnance weight of the 57 statute mile range 280mm sabot. Long range 16-inch projectiles are lighter approximately 30% the weight of the standard full size 25 mile range projectiles. The one hour rate of fire for the 16-inch gun is 9 rounds per ship per minute. The surge rate in the chart is 14 rounds per ship per minute – four rounds short of the documented maximum sustained rate; The 16-inch Mk-VII rifle of the *Iowa* class battleships were designed to fire 2 rounds per minute at a sustained rate. See Arthur R. Romano. "Reactivation of 16-inch Three Gun Turrets in the Battleship," *24th Annual Technical Symposium 1987* (Washington, DC: Association of Scientists and Engineers of the Naval Sea Systems Command, March 1987), 8; DDG-51 ERM capacity is 232 rounds, the DDG-1000 and its AGS system is 600 projectiles. The rates of fire for the AGS is cited as 12 rounds per minute per gun, the ship can fire 24 rounds per minute sustained, and empty its magazines in 25 minutes. The ERM has a sustained rate of fire of about 4 rounds per minute and can empty its 300 round magazine in about 90 minutes with a well-trained crew. Weight of ERM projectile cited at 110 pounds. No weight is given for LRLAP projectile. See *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*, 8-6, 8-7, B-10.

In weight of ordnance delivered to the target in one day, a single Capital Surface Warship equals or exceeds the capabilities of a single aircraft carrier. The aviation strike package in this analysis is forty FA-18 Super Hornet aircraft all carrying max ordnance loads operating under ideal conditions. This assumes no aircraft diverted for local air defense or offensive counter air operations. CSW major caliber gun ranges extend to 400 miles with a scramjet or rail gun. This analysis does not address missiles that would be carried by the surface warships, nor does it address tactical timeliness, ordnance suitability, or cost of aircraft losses penetrating a hostile air environment. Even without considering those additional factors, the capabilities of the CVN and CSW are significant.

For one day's firing, the Extended Range Munition-equipped DDG-51 and the DDG-1000 provide 4% to at most 11% of the weight of ordnance of the CSW. More importantly, they quickly run out of munitions. The number of rounds carried by each ship is limited and can be fired within an hour at the maximum sustained rates of fire.[310] Moreover, these smaller shells provide much less lethality in a major combat operation against a competent foe presenting a target rich environment.

From a very macro, pure operations and support cost perspective, an incremental add of equivalent or greater lethality to the aircraft carrier is possible by adding *four* capital surface warships to the fleet at an annual cost less than the cost to support *one* additional aircraft carrier. The operating cost of CVN air capability is approximately seven times the operating cost of major caliber gun-based capability of a CSW. The need for greater firepower exists to oppose a near-peer competitor in post 2015 time frame.[311]

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[310] *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*, 8-6, 8-7, B-10. DDG-51 ERM capacity is 232 rounds, the DDG-1000 and its AGS system is 600 projectiles.

[311] JCS, *JOC Major Combat Operations (2004)*, 3, 65. The JOC states "the sheer scale of a peer changes the character of the fight. As a result, developing the capabilities identified in this version of the concept will not provide all of the capabilities needed to address either Case Two or Case Three." The JOC identifies three cases to plan for, with case III being the near-peer competitor. The JOC further states "The concept outlines three cases of major combat operations. Of the two likely cases, Case One, the high-end regional competitor, has the greatest impact on our total capability requirements and is accordingly the

FY07 Constant Dollars ($M)	Number of	Total Ave. O&S
Ship and Data Class	Ships	FY03-05
CVN-68 Ship and Airwing	11	$7,528
Surrogate Capital Surface Warship	4	$417

Table 26: Average costs for total number of ships at the macro level

For the operations and support costs of maintaining the 11th or 12th carrier at about $650 million per year, the U.S. can operate four capital surface warships and increase its littoral and blue water capabilities fourfold with dollars to spare. This is a significant addition of flexibility to the fleet. The construction of four new capital surface warships would create a major boost to the U.S. shipbuilding industry, which even as early as 1981 depended, and still depends heavily, upon defense shipbuilding contracts.[312]

Mission capabilities in brief: Aircraft carriers are the centerpieces of Carrier Strike Groups (CSG). They provide Offensive Combat Air, Defensive Combat Air, deep air strike, and close air support which often substitutes for NSFS and artillery for ground troops. Additional capabilities include services such as repair shops, medical, dental, robust communications architecture, operations of Unmanned Aerial Vehicles (UAV) and robust Intelligence, Surveillance and Recognizance (ISR) assets. [313] RAND states;

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focus of Version 1.0. Case Two, major irregular combat is the other likely case in the 2015 time frame and will be the next case developed in future versions of the concept. Case Three, the peer competitor, while the most dangerous, is not anticipated within the time frame of focus and will be the last of the three developed." The July 2006 Draft MCO JOC does not identify planning for a near-peer competitor.

[312] Congressional Budget Office, *Building a 600-Ship Navy: Costs, Timing and Alternative Approaches* (Washington, DC: Congress of the United States, March 1982), 39-40. In 1981, the industry had only six commercial vessels on order. In 1980, there were only seven vessels on order. Military shipbuilding orders are the life blood of the U.S. shipbuilding industry; Congressional Research Service, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* (Washington, DC: Library of Congress, 14 August 2006), CRS-26, CRS-53. This CRS report identifies a 15 year reduction in the shipbuilding industrial base of the United States. There is also discussion of a need to re-invigorate the shipbuilding industrial base; U.S. Department of Commerce, Bureau of Export Administration (BXA), *National Security Assessment of the U.S. Shipbuilding and Repair Industry (003-009-00719-4) May 2001* (Washington, DC: GPO) accessed 24 January 2007 at http://www.bis.doc.gov/defenseindustrialbaseprograms/osies/defmarketresearchrpts/shipbuilding_and_repair.pdf . Documents states that about 95% of the revenues of America's six largest shipyards is defense related. Document further states the U.S. shipbuilding industry is not commercially competitive. 97% of U.S. trade is carried in foreign made vessels.

[313] John Gordon IV, and others, eds. *Leveraging America's Aircraft Carrier Capabilities* (Santa Monica, CA: The RAND Corporation, 2006), 10-19.

> Carrier operations today "provide on-call close-air support, armed reconnaissance and surveillance, airborne command and control, as well as electronic warfare support to the multinational forces in Iraq" and are heavily focused on supporting maritime interdiction operations (MIO) throughout the world, using the air wing's reconnaissance capability to help "detect, disrupt and deter international terrorist organizations while providing security and stability in the maritime environment [in] the North Arabian Gulf."[314]

Battleship and aircraft carrier capabilities do overlap.[315] Battleship 1980s missions were:

1) Operate offensively with carrier task forces in the highest threat areas.
2) Operate backed by appropriate escorts, without carrier air cover in lesser threat areas.
3) Support amphibious groups.
4) Conduct offensive operations against surface and shore targets.
5) Provide their own close-in defense against aircraft and anti-ship missiles.
6) Conduct naval gunfire strikes against hostile shores.
7) Control aircraft.
8) Operate and refuel all types of navy helicopters.
9) Refuel escorts.
10) Establish naval presence.
11) Ease severe pressure on carrier deployment cycles.[316]

The Navy has always considered battleships *additive*, however, they are complementary and can substitute for carriers in certain situations.[317] Gun strike missions do not risk pilots or sensitive technologies to capture. Losses of pilots in Iran, Lebanon and Syria in the 1980's had profound effects upon American policy.[318] Gun ranges up to 400 nautical miles using scramjet and other technologies provide lethal deep strike comparable to and potentially more persistent than air fires.[319] Battleships have proven their ability to use Unmanned Aerial Vehicles to direct long range gun strikes.[320] Current networked

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[314] Ibid., 11.
[315] Cancian, 9.
[316] Muir, *The Iowa Class Battleships*, 122.
[317] Cancian, 9.
[318] Ibid., 9. The record on pilot recovery indicates that one pilot lost can shut down fires across an entire battlefield. "During the 1972 Easter offensive in Vietnam, all fires from air, artillery and naval gunfire were shut down over the entire battlefield in order to protect one downed pilot."
[319] Cancian, 9-10; Admiral Train Interview. Admiral Train specifically stated "16-inch guns firing technologically advanced munitions to ranges of 300-400 miles greatly improve operational and strategic utility, providing a robust capacity that compliments our aircraft and missile strike capability."
[320] *Conduct of the Persian Gulf War*, 396, 807-808. Page 807 states the battleships flew 151 UAV sorties for 520 hours. Page 808 states USMC UAV's flew 138 missions for 318 hours. Page 396 states VII Corps UAV's became operational on 1 February and flew 43 UAV missions prior to the end of hostilities. From data available in the report, it appears the bulk of Desert Storm UAV missions were flown from battleships.

sensors provide additional capability to support gun strikes. The large size and ability to host the required support capability potentially makes a capital surface warship a truly formidable opponent. Admiral Train further expands upon this theme by stating:

> Bringing back the Iowa class ships is appropriate to provide the utility of a Capital Surface Warship to the fleet. It is not appropriate to reactivate them solely for Naval Surface Fire Support. They are capable of performing many more missions and would be greatly underutilized if restricted to NSFS mission set.[321]

Significantly, Admiral Train does not support reactivation solely to solve the NSFS gap as the ships have far greater potential capability.[322]

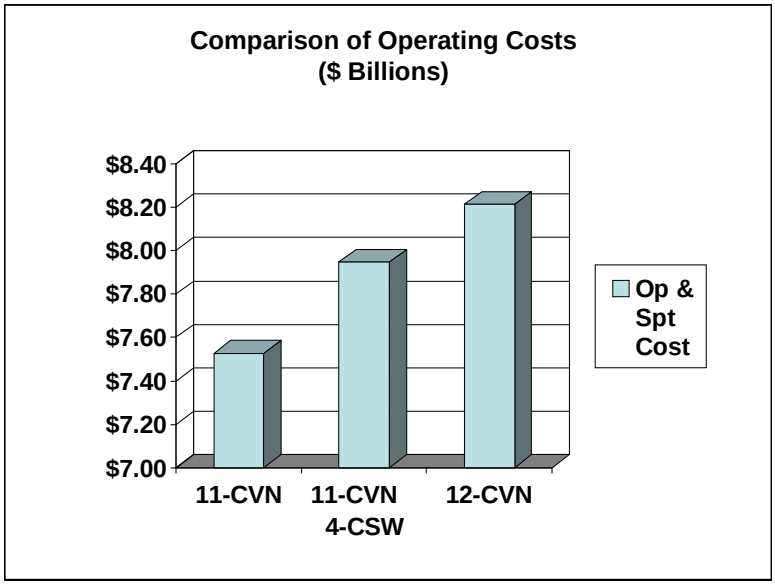

Figure 3: Graphic Comparison of Operating Costs for CVN and CSW mix.

Summary: Appearing about 18 years in the future, a near-peer competitor such as China will be more *infinitely* more formidable than either Iraq or Afghanistan. This is the time required to build and field the CSW based current acquisition experience. Construction costs for two CSWs are additive to the current program unless one less CVN and air wing is acquired. Operations and support costs for an aircraft carrier and its air wing are almost seven times greater than a single CSW, lowering overall costs over the lifetime of the CSW. The CVN and CSW have roughly the same ordnance weight on

[321] Admiral Train Interview.
[322] Ibid.

target at ranges of 40 miles or greater. If the capital surface warship is within 20 miles of the target, the weight and volume of ordnance exceeds that which two aircraft carriers and their air wings can deliver in a 24-hour period. Precision guidance applied to CSW munitions makes them even more formidable. A CSW has 11% to 15% of the operating cost and roughly 47% to 50% of the acquisition cost of an additional nuclear aircraft carrier and air wing. When placed in ends-ways-means construct, the CSW can greatly increase lethality and flexibility to expand the “ways” requiring less “means” or resources. In Chapter 8, construction, operations and support costs are risk evaluation criteria.

Chapter 8: Recommendation and Conclusion

The United States must deploy a robust NSFS capability before a near-peer competitor emerges to challenge the United States. This competitor, as discussed in Chapter 1, will arrive post 2015, more likely in the 2020 to 2025 time period.

Major Caliber Guns: A review of the available analysis since the CNA COEA of the mid 1990s, finds major caliber guns have not been considered. A robust analysis of major caliber guns must be conducted independent of the need for a new ship platform. The intent is to determine their true potential capabilities in the tactical, operational and strategic joint fires portfolio. The following should be included in the new analysis:

1) Current conventional major caliber gun technology (baseline is existing 16-inch guns).
2) Advanced conventional major caliber gun technology.
3) Future technologies such as electro-magnetic rail gun.
4) Lethality for both small/soft targets and large area targets.
5) Hard target penetration (preplanned and emergency tactical fires).
6) Timeliness standards equivalent or better than the Army's PALADIN self-propelled howitzer.
7) Assess all previously considered/tested extended range technologies with a range goal of 400 nautical miles.
9) Logistics sustainability – specifically munitions underway replenishment capability.

Impartially approached, the indicators suggest that the significant potential of major caliber naval guns for the Joint Force Commander will be confirmed.

Robust NSFS capability: Five Courses of Action (COA) were evaluated to prepare the NSFS solution for the near-peer competitor:

1) Current program adding twelfth CVN and seven new DDG-1000 ships.
2) Add thirteenth CVN and seventeen DDG-1000 ships.
3) Four single or limited-mission commercial hull ships dedicated to NSFS.
4) Four Capital Surface Warships.
5) Four Capital Surface Warships and bridge to the CSW by modernizing and recommissioning two *Iowa* Class ships.

Table 26 identifies the risk cost analysis categorization and ranking construct that evaluates the five courses of action.

Risk Category	Risk to Strategic Objective	Cost	Score
Low	Assured	Low	4
Moderate	Very Likely	Moderate	3
Significant	Likely	Significant	2
High	Extraordinary Measures	High	1

Table 26: Risk and Cost Analysis Category Scores

Risk Categories and weights: Each of the nine categories listed in Table 27 relates to specific topics addressed within the body of the thesis and in some cases expanded upon in the appendixes. Each of the categories is defined and weights explained as follows:

1) Near-Peer Competitor: Increase in level of firepower in the long term.
2) Regional Competitor (before 2012): Increase in level of firepower in near term.
3) Survivability: Ability to operate in harms way and support ground force in littorals.
4) Effectiveness (penetration/lethality): Munitions capability to penetrate hard targets and lethality across the spectrum of targets. Major caliber guns earn a 4 rating.
5) Effectiveness (volume fires): Ability to provide significant volume fires as USMC requires.
6) Cost (construct): One time cost to build.
7) Cost (operations and support): Annual recurring cost across the lifetime of the platform.
8) Gain operational experience: ability to quickly gain experience operating the platform in the fleet.
9) Manpower requirement: Number of men required to operate the platform.

Reasoning for weights greater than one are:

1) Near-Peer Competitor: Loss against this opponent has catastrophic implications.
2) Survivability: Closing to support the ground force greatly increases platform risk. The loss of a ship would be most damaging to U.S. prestige. Survivability supports robust presence and shaping of the operational environment.
5) Effectiveness (volume fires): This is a critical requirement as stated in USMC requirements documents and in reports to congress.
7) Cost (operations and support): The annual recurring cost has greater long-term impact upon the budget/program than do construction costs. As cited earlier in the study, this is the cost that the Navy states it is most interested in reducing.
8) Gain operational experience: Operational experience is central to understanding how to employ the capability. Since this type of capability has not been resident to the fleet for almost 17 years, returning that capability as quickly as possible ensures operational viability when the near-peer competitor appears.

Table 26 shows the final ranking of the courses of action. The material presented in each chapter and appendix of this study supports these conclusions. Points are awarded based upon ranking by category. See Appendix H for additional explanation.

Risk Category	Weight	COA #1 - Current Program	COA #2 - 13th CV & 17 DDG-1000	COA #3 - Fire Support Ship	COA #4 - CSW	COA #5 - CSW with BB Bridge
Near-Peer Competitor (post 2020)	2	2	6	4	8	8
Regional Competitor (before 2012)	1	1	1	3	1	4
Survivability	2	2	4	2	8	8
Gain operational experience	2	8	8	4	2	8
Effectiveness (penetration/lethality)	1	2	2	2	4	4
Effectiveness (volume fires)	2	2	4	8	8	8
Cost (construct)	1	4	1	4	3	3
Cost (operations and support)	3	6	3	12	12	12
Manpower requirement	1	3	1	4	4	4
Total Score =		30	30	43	50	59

Table 27: Risk and Cost Analysis of Options

COA 1 – Current program: This course of action is currently funded in the Navy program. The seven DDG-1000 ships and the five aircraft carriers (including the twelfth) will be built. They are included in this analysis as an illustration that currently programmed capabilities are inadequate. The twelfth CVN and air wing could provide the required funds to construct two CSW in a two-for-one trade. Building seven DDG-1000 ships is assumed assured in all courses of action.

COA 2 – insufficient for required NSFS: This course of action is unfunded. While providing seventeen more DDG-1000 ships, still does not fully address the specifics of the requirements articulated by the USMC. While there will be many more DDG-1000 vessels available in time for the near-peer competitor, there will be no major caliber guns and limited (ship massing required) volume fire capabilities. The twenty-four DDG-1000 ships (adding the previous seven constructed) and additional CVN add significant capability to the fleet, but at a significant cost. The construction cost of this option is $120 billion vs. $42.7 billion and operations costs are $2.18 billion opposed to $610 million for COA 5.

COA 3 – a commercial hull with major caliber guns and missiles: While this may gain a ship within five to eight years in the future, as discussed earlier, new major caliber guns and munitions will likely be fifteen to twenty years distant. Given the long gestation period of 5-inch ERM munition and the 155mm Advanced Gun System (both minor caliber), as well as significant technical problems, the track record for rapid development and fielding does not look promising. The lack of survivability of a commercial hull will likely reduce the ship's effectiveness against a regional competitor, and for certain against a near-peer competitor. While it is very likely this ship will be more than a match for the average regional competitor in terms of hitting power, the near-peer competitor would be much more likely to destroy or disable this ship as opposed to a highly survivable CSW. To garner a major caliber gun system that is ready to go to sea within five to ten years on a commercial platform is not likely. That task will probably require 15 years. This is not a *Capital* ship. It is more akin to a *weapons barge* with great firepower and a glass jaw. A loosely estimated construction cost of $4 billion for each ship is applied as no official construction costs have been published.

COA 4 - no bridge to the future: The lack of operational capability of a CSW during the design, construction and initial operations of the new CSW adds additional risk to handling a robust regional competitor. It also increases the difficulty to develop operational and employment concepts for the CSW, and reduces the likelihood of achieving system deployment maturity in time for use against the emerging near-peer competitor. This option ensures approximately fifteen to twenty years before the first ship is available for operational employment.

COA 5 – provides a bridge to the future: The fifth option is likely the most operationally (ways) and cost (means) effective option to increase firepower to win decisively in the littorals against both a regional niche competitor with significant anti-

access capabilities and the future near-peer competitor. Regional niche competitors with significant anti-access capabilities such as North Korea and Iran exist today. A bridge platform that is active during the construction of the CSW provides additional required firepower. The only option for the near term is the modernization of the two remaining *Iowa* class ships. Modernization and reactivation provides the Navy with platforms to experiment with operational concepts, major caliber guns and other technologies. It also provides the ability to surge a significant NSFS capability for use against a niche-capable regional competitor. Reactivation costs likely exceed $1 billion per ship which is far less expensive than construction of a commercial hull fire support ship. While it is beyond the scope of this study to analyze the pros and cons of the mechanics related to battleship modernization and reactivation, some of the evidence already cited in the body of this work and in Appendix G indicates it is within the capabilities the American industrial base and of the Navy to reactivate these ships for the time required to design, build and bring to full operational capability the future Capital Surface Warship. Given the significant modifications applied to the ships in the 1980's, it is likely the Navy could have these ships ready within two to three years for their first deployment. They would arrive in the fleet in time to team with the first DDG-1000's. In implementing this option, the following must be applied:

1) Immediately develop and field extended range 16-inch projectiles.
2) Apply precision guidance to all munitions; conventional and extended range.
3) Develop, test and refine concepts for employment.
4) Apply lessons learned to the design and construction of the CSW.

The fielding of the two remaining *Iowa* class ships should only be implemented with the understanding that a new class of highly survivable Capital Surface Warships with major caliber guns will augment and ultimately replace them in the fleet by the time a near-peer competitor emerges to challenge the United States in the littorals.

Conclusion: This study has shown that U.S. national strategy, joint and service doctrine, and joint operating concepts such as those for Major Combat Operations, all require an ability to successfully execute forced entry operations. Review of past littoral operations shows the past employment and importance of robust NSFS. Major caliber guns have proven to be especially lethal. The Navy has successfully developed extended range major caliber munitions, only to cancel the programs after the projectiles have proved successful. The need to destroy battlefield fortifications and hard targets exists today. That need has been met by air power against poor performing adversaries. Greater complementary capabilities are available from major caliber guns at far less cost. The capabilities of capital ships with major and minor caliber guns have been clearly identified in analysis conducted prior to 1990. Since then, major caliber guns on large warships have not received any analytic evaluation to ascertain their true capabilities to support the joint fight. The potential ability of the CSW to supplement and in some instances replace the fires capabilities of an aircraft carrier has been proven. The CSW demonstrated significant hitting power in the FireSim XXI OMFTS simulation and within the synthetic environment demonstrated great potential to complement U.S. airpower and extend the reach of operational strike. While no simulation is a perfect predictor of battlefield performance, the indications from this limited effort are that the CSW is a potent joint force multiplier. From a cost and effectiveness perspective, choosing to add four CSW to the fleet as opposed to building the twelfth or thirteenth aircraft carrier and constructing seventeen additional DDG-1000 ships provides greater flexibility (ways) for the Joint Force Commander at far less cost (means).

This thesis has been proven. Ways and means must be determined to return major caliber guns and the capital surface ships that mount them to the fleet in time to defeat the future near-peer competitor in the littorals.

Appendix A:
Glossary

AoA	Analysis of Alternatives
ACAT	Acquisition Category
ACTD	Advanced Concept Technology Demonstration
AEGIS	Combat system consisting of an integrated combination of sensors, weapons, computers, software, and display systems that was named for the mythological shield carried by Zeus.[323]
AFATADS	Advanced Field Artillery Tactical Data System
AGS	Advanced Gun System (155mm)
AHP	Analytic Hierarchy Process
ATACMS	Army Tactical Missile System
AP	Armor Piercing
BA	Battlespace Awareness
BB	Battleship
C2	Command and Control
CA	Heavy Cruiser
CAS	Close Air Support
CBA	Capabilities Based Assessment
CCF	Course Correcting Fuse
CCJO	Capstone Concept for Joint Operations
CDD	Capability Development Document
CG	Guided Missile Cruiser
CID	Combat Identification
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CJCS	Chairman of the Joint Chiefs of Staff
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CJCSM	Chairman of the Joint Chiefs of Staff Manual
CL	Light Cruiser
CNA	Center for Naval Analysis
ConOps	Concept of Operations
COCOM	Combatant Command
CONUS	Continental United States
COEA	Cost and Operational Effectiveness Analysis
CRD	Capstone Requirements Document
CSG	Carrier Strike Group
CSW	Capital Surface Warship
CVN	Nuclear Aircraft Carrier
DD(X)	Land Attack Destroyer Navy program of record 2001 to 2006
DD-21	Land Attack Destroyer Navy program of record 1997 to 2001
DDG-51	Arleigh Burke Class Guided Missile Destroyer
DDG-1000	Land Attack Destroyer Navy program of record 2006 to present

[323] Congressional Research Service. *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress (CRS Order Code RS22595)* (Washington, DC: Library of Congress, 1 February 2000), 1.

DoD	Department of Defense
DoN	Department of the Navy
DOTLPF	Doctrine, Organization, Training, Leadership and Education, Personnel, and Facilities
DOTMLPF	Doctrine, Organization, Training, Leadership and Education, Materiel, Personnel, and Facilities
DPG	Defense Planning Guidance
DPS	Defense Planning Scenarios
ERGM	Extended Range Guided Munition
ERM	
ESG	Expeditionary Strike Group
F2T2EA	Find, Fix, Track, Target, Engage, Assess
FA	Force Application
FAA	Functional Area Analysis
FAAD	Force Application Assessment Division
FCB	Functional Capabilities Board
FNA	Functional Needs Analysis
FOC	Full Operational Capability
FSA	Functional Solution Analysis
FY	Fiscal Year
GAO	Government Accountability Office
GIG	Global Information Grid
GWOT	Global War on Terror(ism)
GPS	Global Positioning System
Gunfighter	Navy program of record to develop long range gun munitions in late 1960's
HIMARS	High Mobility Artillery Rocket System
ICD	Initial Capabilities Document
ICM	Improved Conventional Munitions
IOC	Initial Operational Capability
IPT	Integrated Process Team
ITWA	Initial Threat Warning Assessment
ISR&T	
J-8	Joint Staff Force Structure, Resources and Assessment Directorate
JCB	Joint Capabilities Board
JCIDS	Joint Capabilities Integration and Development System
JDAM	Joint Direct Attack Munition
JFC	Joint Functional Concept
JFEO	Joint Forcible Entry Operations
JIC	Joint Integrating Concept
JMEM	Joint Munitions Effectiveness Manual
JOA	Joint Operating Area
JOC	Joint Operating Concept
JOPES	Joint Operation Planning and Execution System
JROC	Joint Requirements Oversight Council
JV 2020	Joint Vision 2020
LGB	Laser Guided Bomb
LRLAP	Long Range Land Attack Projectile

MA	Mission Area
Major Caliber Gun	A gun with a bore 12-inchs in diameter or larger
MCO	Major Combat Operations
MCS	Marine Corps Strategy
MEB	Marine Expeditionary Brigade
MLRS	Multiple Launch Rocket System
MRC	Major Regional Conflict
MTI	Moving Target Indicator
NC	Net Centric
NDS	National Defense Strategy
NEA	North East Asia
NM	Nautical Mile
NMS	National Military Strategy
NOC	Naval Operating Concept
NSFS	Naval Surface Fire Support
NSS	National Security Strategy
NTR	Navy Transformation Roadmap
OCONUS	Outside Continental United States
OEG	Operational Evaluation Group
OSD	Office of the Secretary of Defense
OMFTS	Operational Maneuver from the Sea
O&S	Operations and Support
PALADIN	Self-propelled howitzer that is global position finding enabled to generate its own firing data, greatly increasing mission response time
PIA	Post Independent Analysis
PGK	Precision Guidance Kit
QDR	Quadrennial Defense Review
ROM	Rough Order of Magnitude
ROMO	Range of Military Operations
RSO&I	Reception, Staging, Onward Movement and Integration
SACEUR	Supreme Allied Commander Europe
SC-21	Land Attack Destroyer Navy program of record 1994 to 1997
SDB	Small Diameter Bomb
SEA	South East Asia (Middle East)
S/NF	Secret, No Foreign
SOF	Special Operations Forces
SPD	Strategic Planning Directive
SPG	Strategic Planning Guidance
STA	System Threat Assessment
STAR	System Threat Assessment Report
STOM	Ship to Objective Maneuver
TACAIR	Tactical Air Support
TACTOM	Tactical Tomahawk Missile
TCA	Threat Capabilities Assessment
TPG	Transformation Planning Guidance
TRADOC	U.S. Army Training and Doctrine Command

TRAC WSMR	TRADOC Research and Analysis Center at White Sands Missile Range
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
UJTL	Universal Joint Task List
U.S.	United States
USA	United States Army
USAF	United States Air Force
USJFCOM	United States Joint Forces Command
USMC	United States Marine Corps
USN	United States Navy
VAMOSC	Visibility of Operating and Supporting Costs (Navy financial database of record)
VLS	Vertical Launch System (shipboard missile magazine/launch system)

Appendix B:
Detailed Overview of CNA NSFS Cost and Economic Analysis report

The material contained within the Center for Naval Analysis (CNA) documents provides a number of insights into NSFS requirements. The catalyst for the COEA was Congress' direction to the Navy to establish an NSFS research and development program due directly to the reduction in naval guns in the fleet and the retirement of the last battleships in 1992.[324] The then current emphasis on amphibious assault from over the horizon as well as the retirement of battleships was cited as factors in the decision to initiate the COEA.[325]

The eight options recommended by the COEA varied in priority from a new 155mm/60-calibre gun with a family of rocket-assisted, precision guided munitions to a new 8-inch/55 caliber light weight gun with advanced precision guided munitions.[326] In addition to initial observations cited in Chapter 2, CNA stated that because of sunk costs, Tomahawk land attack missile was the likely choice to fulfill the missile requirement.[327] This holds true today. Peacetime life cycle and sunk costs were primary drivers in this observation. All of these gun and missile options were cited as mid-term solutions with a 2003 Initial Operating Capability. Not one of the options identified included a 5-inch type gun.[328] A 5-inch/70 caliber gun was identified separately from the observations and recommendations as being able to save money in the near term; however, it would be more costly in war. The higher cost was attributed to the greater number of rounds

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[324] CNA, *NSFS COEA*, Cover Letter.
[325] Ibid., 7.
[326] Ibid., 4-5; The eight recommendations include a new 155mm gun, the same gun coupled with one of four different guided missiles, and three separate types of 8-inch guns. One of the reasons that a 5-inch gun was not in the recommended list was the lack of lethality to address a significant portion of the target set. Near-term budget constraints, as opposed to effectiveness, were cited as a reason for this option to become attractive.
[327] Ibid., 3-4.
[328] Ibid., 4-5,; *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 2, 3. While the GAO was not provided the final COEA report, they did get the list of recommendations and noted in their report that the 5-inch gun was not a recommended solution.

needed to achieve the desired effects on the targets or the need to attack targets with aircraft or missiles.[329] The fact that 5-inch guns were not recommended is significant given the continued emphasis on 5-inch Extended Range Munition.[330]

CNA Wartime Cost for Gun Systems ($K)	Total Targets Attacked	Total Rounds Fired	Percent Attacked	Total cost	Cost per Target	Ave rounds per Tgt
		Desert/Mountain Scenario				
5-inch/54 cal Std Propellent (SP)	8	684	3	27,416	$3,427	85.5
5-inch/54 cal Adv Propellent (AP)	24	972	10	38,592	$1,608	40.5
5-inch/70 cal AP	88	3,526	37	134,390	$1,527	40.1
155mm/52 Cal AP	123	1,668	52	92,306	$750	13.6
155mm/60 Cal AP	221	2,433	94	133,168	$603	11.0
8-inch/55 cal SP	221	1,585	94	110,579	$500	7.2
8-inch/55 cal AP	224	1,531	95	111,799	$499	6.8
8-inch/60 cal AP	224	1,364	95	101,222	$452	6.1
16-inch/50 Cal SP	33	224	14	13,442	$407	6.8
		Heavily Defended Scenario				
5-inch/54 cal Std Propellent (SP)	182	6,496	64	255,414	$1,403	35.7
5-inch/54 cal Adv Propellent (AP)	188	5,484	66	224,781	$1,196	29.2
5-inch/70 cal AP	237	2,813	83	110,262	$465	11.9
155mm/52 Cal AP	238	2,286	84	124,556	$523	9.6
155mm/60 Cal AP	253	1,431	89	74,899	$296	5.7
8-inch/55 cal SP	253	1,179	89	76,662	$303	4.7
8-inch/55 cal AP	253	1,166	89	79,506	$314	4.6
8-inch/60 cal AP	253	1,166	89	79,506	$314	4.6
16-inch/50 Cal SP	199	1,324	70	71,359	$359	6.7

Table A-1: CNA Wartime Cost Summary for Gun Systems[331]

The chart above shows clearly that 5-inch guns required many more projectiles to achieve the desire effect upon attacked targets. This is due directly to the lack of lethality of what are the smallest projectiles considered in these studies. These findings are consistent with those seen in the FireSim XXI simulation in Chapter 6.

All initially recommended weapon systems were subjected to a pre-screening analysis that eliminated candidates based upon clear lack of cost effectiveness or not

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329 CNA, *NSFS COEA*, 4-5; *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 3, 7.

330 *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 3. The GAO stated the 5-inch/70 caliber gun would not cover adequately the targets. This is a specific reference to a lack of lethality on the part of the projectile.

331 CNA, *NSFS COEA*, 90. This chart was declassified by OPNAV, N86. Declassification notification maintained by Joint Forces Staff College Ike Skelton Library. The Average Rounds Per Target column was calculated by the author from data available in this chart in rounds fired and targets attacked. SP indicates "standard propellant and "AP" indicates "advanced propellant." The abbreviation "Cal" identifies the caliber or length of the gun tube which is bore diameter multiplied by the caliber length.

achieving Initial Operating Capability (IOC) by 2003.[332] Consistent references in the CNA COEA to peacetime costs as opposed to wartime costs indicate a need to ensure all costs are considered against operational effectiveness of the projectile in question as the primary consideration. To a significant degree, peacetime vs wartime costs should be secondary to overall combat effectiveness. Given the high cost of aviation delivered ordnance, it appears the Navy applies two separate cost screen criteria to this discussion.

The COEA was organized into five task areas: (1) System Definition, (2) Cost Analysis, (3) Lethality, (4) Scenarios and Targets, (5) Operational Effectiveness Analysis. There were two appendixes, one on TACAIR in NSFS, and the other an Extended Range Excursion which looked at a hypothetical 10-inch naval gun.

System Definition: The definitions portion included cost analysis and attention was confined to NSFS systems (guns and missiles). After submission of the COEA, the Navy directed CNA to consider whether the NSFS mission could be handed entirely with TACAIR.[333] Though NSFS and TACAIR can overlap, past decisions to maintain a distinct NSFS capability would apply due to immediate responsiveness sortie generation requirements and weather (poor visibility conditions).[334]

Cost analysis: The CNA COEA based cost analysis upon a 20-year life cycle and replacement costs (stockpile replenishment or "wartime" costs) for individual missiles and projectiles expended in the scenarios examined. The 20-year life cycle includes development, procurement and peacetime operating and support costs.

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[332] Ibid., 11. The 2003 operational data was used to screen out the 16-inch gun as it was assumed by that date the battleships would be completely removed from the reserve fleet.

[333] Ibid., 2.

[334] Center for Naval Analysis, Memorandum for Major General H. W. Jenkins (N85) and Mr. Ronald Kiss (DASN (Ships)), Co-Chairs, NSFS COEA. Subject: Naval Surface Fire Support (NSFS) COEA, TacAir attachment, 10: "…the real issue is the operational drawbacks and uncertainties of exclusive reliance on TacAir: Slow response to urgent calls for fire (or high costs to maintain a responsive posture), ability to generate sufficient sorties, impact on other missions, risks of hitting friendly troops, and interference by weather."

In regards to costing ship systems proper, the COEA states "to avoid arbitrarily limiting our options, we had employed an approach that began with proposed weapon systems, not with proposed ship configurations." The COEA continued by stating that it was important to take the most promising systems and combinations of systems and assess the feasibility of integrating these onto a ship.[335] However, major caliber gun systems (16-inch) were subject to different cost analysis than the 8-inch and smaller guns.

> ...life-cycle costs (peacetime costs) for the ships on which these weapons systems would be installed are not considered. Appropriate ships are already programmed in sufficient numbers, and will presumably be produced independent of any NSFS decision. Ship modification and system integration and installation costs are included. [336]

The statement "appropriate ships are programmed" in the paragraph above shows that major caliber guns were subjected to a different cost analysis defined as follow:

> O&S costs for the 16-inch guns include the costs to operate the battleships because they exist primarily for the 16-inch guns themselves. O&S costs for other guns include costs for the guns but not the ships on which they are mounted because they are multi-mission platforms. [337]

This approach to cost analysis removed large guns from favorable consideration regardless of their operational effectiveness. Further, the "single mission" assumption for capital surface warships is not supported by the past employment of the battleship platform. These ships executed a multitude of missions including logistics functions such as refueling escorts, metal work, electric component repairs, as well as command and control, intelligence collection and anti-ship operations with either guns or missiles.[338]

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335 CNA, *NSFS COEA*, 9.
336 Ibid., 33.
337 Ibid., 37 and 38.
338 Larry Seaquist, Captain, USN, "The BBs are Capital Ships," *Proceedings*, August 1989, 65; Captain Seaquist identified the ability of the battleship to refuel and support escorts as an important capability; Norman Friedman. *U.S. Battleships: An Illustrated Design History* (Annapolis, MD: Naval Institute Press, Reprinted, 1987), 326-327 and 389; Interview, Captain (retired) Coenraad van der Shcroeff, 27 September 2006, 3 Jan 2007; ship logistics support is a major capability. The repair shops include major metal work, electric motor rewind, communications repair and refueling. During the 1980's the battleships would provide repair and refueling support to smaller ships, stretching the Navy's dollar and maintaining readiness. The anti-ship role of the battleship was underappreciated according to Captain van der Schroeff. On the intelligence gathering capabilities of the battleships, Captain van der Schroeff stated the "AN/SLQ-32…full up version an even broader frequency spectrum for alert and intelligence collection. The BB,

While in-depth discussion of these capabilities is outside the scope of this paper, the fact these types of capabilities existed and were employed indicates that adding the O&S cost of the ship to that of the 16-inch gun is inappropriate at best. It does not address any cost efficiencies gained by the fleet as a result of applying a capital surface warship's inherent logistics infrastructure, nor does it consider the advantage of available space on a capital surface warship to accommodate additional capabilities.

Gun program development risk analysis assessments were conducted considering technical, safety and shipboard integration. Of all the possible advanced gun systems (5-inch, 155mm and 8-inch), the 16-inch gun was rated the least risky for future long range development.[339] Adding to the risk considerations, of all the projectiles considered, the 16-inch gun was the only system where the proposed munitions upgrades assessed (1,050 pound 38 nautical mile range sabot) had actually been proven in test firings.[340] All of the other projectiles were hypothetical or, in the case of the 5-inch extended range projectile, just beginning design.

	RDT&E Cost
Projectile Family	**(FY93, $M)**
5-inch	$182
155mm/52 cal	$215
155mm/60 cal	$226
8-inch	$340
16-inch	$72

Table A-2: Advanced projectile Research, Development, Test and Evaluation (RDT&E) costs [341]

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although not as tall as the Aircraft Carrier, carries the antennae high and away for the many emitters that a warship typically caries and as such provided excellent clean collection capability. The above is an operational experience and as such has no statistical basis, what I can say is that when compared to the capability of the SLQ-32 installed in the CG-22, the BB had, in the same environment, many more detections."

[339] CNA, *NSFS COEA*, 30-31. The risk assessment was scaled zero to forty for development risks for standard propellants, and three new propellants for the gun based systems. Interestingly, the final risk ratings showed the standard propellants to be the least risky, and of the three gun systems analyzed for overall advanced development, the 16-inch/50 was the least risky (rating: four) with 5-inch/54 most risky (rating: eight). For the three new propellants, risk ratings for all analyzed gun systems other than 16-inch/50 were from seven to seventeen. The 16-inch gun was only considered using standard propellants.

[340] Ibid., 55.

[341] Ibid., 39.

Considering the risk ratings and the estimated projectile development costs as shown in the table above indicates the 16-inch extended range projectile was the least costly to develop. In reality, the development costs for both the 5-inch and 155m guns have exceeded the estimates outlined in the chart above.[342] All of the projectiles selected for analysis, with the exception of one 8-inch variety, were to include Global Positioning System (GPS) mid-course trajectory correction. The cost per unit indicated that the 16-inch varieties were less expensive than other types of guided projectiles. In 1995 the GAO expressed concerns with the potential risk of cost overruns with the 5-inch guided extended range projectile.[343] These cost and risk concerns were prophetic.[344]

			(FY93, $K)
Projectile	**Warhead**	**Weight**	**Unit Cost**
8-inch (unguided)	DPICM	250	$13
16-inch	DPICM	1,900	$39
5-inch	HE	25	$46
5-inch	DPICM	25	$47
16-inch	DPICM	1,050	$47
155mm/52 Cal	HE	100	$48
155mm/60 Cal	HE	100	$48
155mm/52 Cal	DPICM	100	$51
155mm/60 Cal	DPICM	100	$51
5-inch	Shaped	40	$57
155mm/52 Cal	Shaped	100	$61
155mm/60 Cal	Shaped	100	$61
8-inch	HE	250	$63
16-inch	SADARM	1,050	$112
155mm/60 Cal	SADARM	100	$124
8-inch	SADARM	250	$145

Table A-3: Projectile Procurement Costs (abbreviated) in order least to highest cost [345]

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[342] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 12, 14.

[343] *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 4-5, 8. GAO stated the 5-inch extended range guided munition (ERGM) program was a "high risk endeavor that requires concurrent technologies." The Navy told GAO that it expected Initial Operational Capability (IOC) in FY 2001. As of this writing in 2007, the ERGM, now titled "extended range munition" (ERM) program is not fielded in any capacity within the fleet. Original cost estimate was for $246m, navy funded in 1995 $160m, leaving shortfall of $86m. The Navy also cut money in 1994 from the NSFS program to fund other USMC priorities. This extended the already lengthy development times.

[344] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 16-17. Original 5-inch Extended Range Guided Munitions research and development estimate was $86m. Navy now projects costs to total $475m, a 550% increase. Shipboard testing is not to begin until at least 2010.

[345] CNA, *NSFS COEA*, 39-40. The projectiles analyzed for development included High Explosive (HE), Dual Purpose Improved Conventional Munition (DPICM – submunitions) and shaped charges for 5-inch, 155mm, 8-inch and 16-inch. The 16-inch did not have a shaped charge projectile. All guns but the 5-inch

The above chart shows the Search and Destroy Armor (SADARM) projectiles to be the most expensive types. The 16-inch is the least expensive and most lethal of the SADARM types due to its inherent volume capacity to carry many SADARM munitions.

From just the RDT&E and procurement costs of the munitions, the larger gun is more cost effective. However consideration of a new 16-inch gun and mount were not addressed, as it was only included in the COEA to serve as a baseline type that already existed. These costs likely are beyond those of the similar guns and a redesigned and enlarged ship platform would be required.

Missile development and procurement cost estimates were considerably higher than any of the gun projectiles. Procurement costs alone spanned between $800 million to $1.5 billion for one thousand missiles. Annual O&S costs for missiles were seven to ten times those of guided gun launched projectiles.[346] Once wartime replenishment costs are incurred for missiles, the guns are far less costly than either missiles or aircraft. During this analysis, not one of the missile alone options performed as well as gun/missile combinations in terms of cost or operational effectiveness.[347] All weapons were graded against a target set that included both command and control bunkers and fighting bunkers as hard targets.[348]

While the COEA and subsequent documents in the series from the Center for Naval Analysis clearly indicate that a larger caliber gun is the most effective option in

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included SADARM (search and destroy armor) projectiles. The 16-inch extended range SADARM shell would have held nine SADARM submunitions vs. one to three for the 155mm and 8-inch varieties. The 5-inch was incapable of holding the SADARM munition. The abbreviation "Cal" identifies the caliber or length of the gun tube which is bore diameter multiplied by the caliber length.

[346] CNA, *NSFS COEA*, 43-45. Four types of missiles were assessed in the COEA: 1) Cruise long and short range, 2) Ballistic long and short range, 3) Gliding long and short range, and 4) Army Tactical Missile System (ATACMS) in Vertical Launch System (VLS) or box launch system.

[347] Ibid., 120-125.

[348] Ibid., 60.

wartime, once the larger gun is assessed, ship costs are immediately applied, skewing the cost analysis.[349]

Lethality Analysis: Much of the lethality analysis focused on the use of submunitions equipped weapons. Submunitions create significant policy and collateral damage issues and free use of them in the current situation and in the future will at best be constrained.[350] The Search and Destroy Armor (SADARM) munition was modeled. However, the statement that it will likely not be procured is interesting as the SADARM proved itself a most potent killer of tanks during Operation Iraqi Freedom.[351] The rest of the lethality analysis was conducted in a similar manner as follow on studies with the munitions addressed being high explosive, submunitions, and SADARM's.[352]

Scenarios and Targets: Most of this section is classified. Three scenarios were modeled, each of which roughly correspond to current threat scenarios. These range from two conventional forced entry actions against modern military opponents (near-peer competitors) to insurgents and special operations forces in a jungle environment.[353] Suppression and preparation fires were modeled as a 100x100 meter area requiring approximately 3000 pounds of high explosive.[354] Hard targets such as fighting and

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[349] Ibid., 121.

[350] The warhead for this 5-inch munition was changed from a submunition warhead to a unitary air burst blast/fragmentation warhead; "British Minister blasts cluster bombs," See U.S. Department of the Navy. *Capability Development Document (CDD) for the Extended Range Munition (ERM)*. Washington, DC: Department of the Navy, 22 May 2006, i. Hereafter cited as *CDD for ERM*; All of the following articles outline the domestic and international pressure to ban the use of submunitions in artillery and bombs. This is similar to the effort that ultimately resulted in the land mine ban of the late 1990's.See *Agence France Press*, 5 November 2006; Elaine M. Grossman, "Senate Defeats measure to ban cluster bomb use in populated areas," *Inside the Pentagon*, Vol 22 No. 36, 7 September 2006; Bradley S. Klapper, "Red Cross steps up campaign against cluster bombs, urges ban," *The Associated Press*, 6 November 2006; John Ward, "Landmine activists urge Canada to act against cluster bombs," *Canadian Business and Current Affairs*, 20 November 2006.

[351] Ibid, 56; Murray and Scales, *The Iraq War*, 99-100.

[352] CNA, *NSFS COEA*, 56-59.

[353] Ibid., 76, 80, 82.

[354] Ibid., 61, 72; David Thompson, 64. This is in keeping with the studies general findings. It was based upon the equivalent of a half pound of explosive per square meter per hour and is close to the approximate level of high explosive needed to create a neutralization effect upon the targeted soldiers.

communications bunkers were also included.[355] Significantly, some targets were allocated to aviation, but not with the intent to analyze aviation as an alternative to NSFS.[356] Of the three scenarios, the first two had 254 and 405 targets respectively. The third scenario had less than 20 targets. Of the two larger scenarios, the first one assigned between 8.6% to 46% of the targets to aviation, and the second scenario assigned between 26.4% and 41.2% of the targets to aviation.[357] Aviation played a significant role in the COEA analysis thought its costs were not factored into the recommendations.

The Navy requested CNA conduct additional analysis after the COEA was published to addresses improvements to naval fire support systems that were nearer term than considered by the COEA.[358] The only guns analyzed in the study were three versions of 5-inch guns because they were the only guns assumed to be capable of reaching initial operating capability by 2001.[359] This study states the Navy had approved funding of the 5-inch upgrade.[360] The GAO in 1995 felt this was done to justify decisions the Navy had already made.[361] This follow-on analysis also did not require "good" options to attack at least 95% of the targets in each target set.[362] Because these were the only guns the study felt were capable of being fielded by 2001, the study recommended proceeding with the new long range 5-inch ERGM guns and munitions, as

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355 CNA, *NSFS COEA*, 60.

356 Ibid., 73. This was intentional to gain an understanding of how the level of aviation support affects NSFS.

357 Center for Naval Analysis. *Scenarios Supporting the Naval Surface Fire Support (NSFS) COEA. CRM 93-157* (Arlington, VA: Center for Naval Analysis, December 1993). While the inclusion of aviation demonstrates consideration of aviation capabilities, it provided no analysis in regards to aviation assuming NSFS missions.

358 Center for Naval Analysis. *NSFS Study: Near-Term Improvements to Existing Guns and Missiles. CNA 95-0147.09* (Arlington, VA: Center for Naval Analysis, 31 July 95), 1.

359 Ibid., 1.

360 *Navy's Near-Term Plan Is Not Based on Sufficient Analysis*, 8-9. GAO noted the study was requested two months after the Navy made the decision to move forward with the 5-inch program. This is incongruent with the COEA determination the 5-inch gun was the least effective option for NSFS. The GAO noted the Navy did not provide GAO with the final COEA report dated October 1994. However the GAO did discuss the COEA with the Center for Naval Analyis.

361 CNA, *NSFS COEA*, 88.

362 *NSFS Study: Near-Term Improvements to Existing Guns and Missiles*, 2.

well as developing a Vertical Launch System (VLS) land attack missile.[363] Fielding an ineffective system (5-inch gun),[364] and then augmenting it with a yet to be designed missile, after the COEA demonstrated the greater effectiveness of a larger gun, indicates the Navy opposed larger caliber guns without regard to their effectiveness.

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[363] Ibid., 6-7.

[364] The eight recommendations in the final COEA did not include the 5-inch gun. One of the reasons that a 5-inch gun was not in the recommended list was the lack of lethality to address a significant portion of the target set. Near-term budget constraints, as opposed to effectiveness, were cited as a reason for this option to become attractive. See CNA, *NSFS COEA*, 4-5; Two key issues further identified in the summary are that 5-inch guns are not in the prioritized recommendation list as they could not successfully engage a large part of the target set, and they had high wartime costs because of the larger number of rounds required to achieve the required effect on the designated target set. See Center for Naval Analysis, Memorandum for Major General H. W. Jenkins (N85) and Mr. Ronald Kiss (DASN (Ships)), 12.

Appendix C:
Detailed Overview of Marine Corps requirements documents

From 1996 to 2002, the Marine Corps Combat Development Command (MCCDC) published three requirements documents addressing Naval Surface Fire Support. The first document was signed by Lieutenant General Paul Van Riper on 3 December 1996. Additional quantifiable standards are established in this memo for killing power in three additional areas, range, volume, accuracy and ammunition.

The range requirement of 41 nautical mile threshold and 63 mile objective is based upon a 25 nautical mile standoff from the shoreline plus 16 nautical miles for the maximum range of friendly artillery.[365] This standoff for the Naval force is in contrast to the assaulting force which will close with the enemy force.

In addition to the range requirement, volume fires are given a quantitative value.

Performance Parameter	Threshold (min)	Objective (min)	10 Min Thrsld	10 Min Obj	30 Min Thrsld	30 Min Obj	DDG-1000 remaining (10 min obj)	DDG-1000 remaining (30 min obj)
Ballistic	16	20	160	200	480	600	400	0
Extended Range Munition	5	10	50	100	150	300	500	300
Lt Weight 155mm (max rate)	5	8	50	80	150	240	520	360
(sustained rate)	2	2	20	20	60	60	580	540

Table A-4: Volume Fire Requirements against 10 and 30 minute time and DDG-1000 munitions loads.[366]

The last two columns of Table A-4 show the impact of firing munitions at the specified performance rates upon a DDG-1000 and its 600 round magazine capacity. If multiple volume fire missions are required, the magazine is quickly exhausted. Van Riper further clarifies the volume fires requirement by the statement that "Quantity of fire, on time and on target, has a quality all its own."[367] Further statements concerning logistic sustainability, which would address magazine capacities and the ability to have

[365] USMC, *MCCDC 1996 NSFS Requirements for OMFTS*, Enclosure 1, 9; *CDD for ERM*, ii.
[366] USMC, *MCCDC 1996 NSFS Requirements for OMFTS*, Enclosure 1, 4. The left two columns are from the MCCDC document, the right six columns in the chart are calculated by the author of this study.
[367] Ibid., Encl. 1, 4.

enough ammunition to sustain firing indicate a requirement for a large number of projectiles to sustain a volume fire capability.[368]

Accuracy is addressed both for precision and "less precise" munitions.

Range	**Circular Error Probable**
18 km	52 meters (high explosive)
30 km	98 meters (rocket assisted projectile)

Table A-5: Current Range and Accuracy Capabilities from LTG Van Riper [369]

Using the then-current (1996) capabilities as a baseline, new precision guidance capabilities outlined later in this thesis can greatly improve accuracy of gun launched projectiles from this baseline. As outlined earlier in this study, several options exist to ensure this level of accuracy or better. The Precision Guidance Kit and its Course Correcting Fuse is one option.

The last enclosure to Van Riper's requirements memo identifies a triad of fires in support of troops and littoral operations, which contained reference to an "Advanced/Larger Caliber Naval Guns." This is the last time a larger, more lethal naval gun is referenced within a Marine Corps or Navy requirements document with the exception of the 155mm Advanced Gun System (AGS) that will be fielded on the DDG-1000. The 155mm AGS is only slightly (approximately one inch) larger than the 5-inch (127mm) guns that will fire the Extended Range Munition (ERM).

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[368] Ibid., Encl. 1, 4; LTG Emil Bedard, USMC Deputy Commandant for Programs stated in 2002 ""The kind of fire support that the Marines need for maneuver ashore in the littorals is not the tactical Tomahawk, it's the kind that comes from a gun….we don't have it [even though] the requirements have been articulated. … We have a hard requirement for a gun. We are not going to fall off from that requirement." This is one of the stronger statements by USMC leadership that a gun based component to NSFS is deemed critical to success for littoral operations. See "Marines Clamor for Long-Range Artillery at Sea."

[369] USMC, *MCCDC 1996 NSFS Requirements for OMFTS*, Enclosure 1, 4.

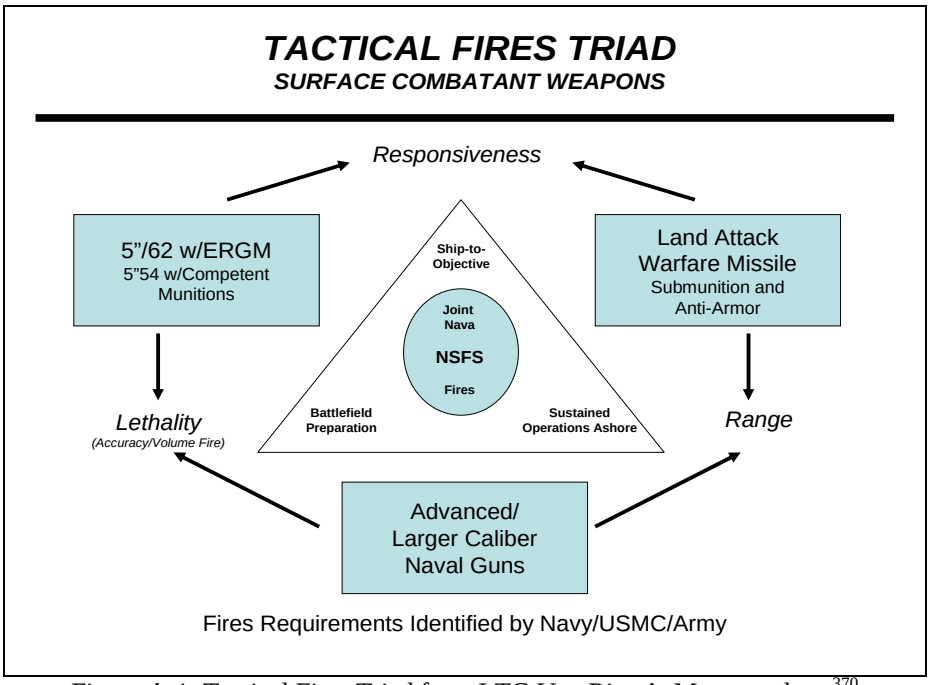

Figure A-1: Tactical Fires Triad from LTG Van Riper's Memorandum [370]

It is significant to note that throughout Van Riper's document there is no mention of specific weapons systems that could meet the stated requirements. Van Riper does express satisfaction at the award of a contract for an improved 5-inch Naval Gun and its Extended Range Guided Munition (ERGM). The likely reason for this satisfaction is this was the first apparent move by the Navy to improve the naval gunfire support situation since the decommissioning of the battleships.

Three years after Lieutenant General Van Riper published the USMC requirement for NSFS, his replacement, Lieutenant General Rhodes, published an updated requirements letter. Rhodes expands upon Van Riper's requirements document, and makes one notable quantitative change. The timeliness requirement is changed from 2 minute 30 seconds from call for fire to rounds impacting to 2 minutes 30 seconds from call for fire to *firing* the first round.[371]

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[370] Ibid., Encl. 2, 1.
[371] USMC, *MCCDC 1999 NSFS Requirements for OMFTS*, Enclosure 1, 7.

Fast response times are critical not just when the friendly forces are taking enemy fire. They are also critical to hitting moving targets. Moving targets can cover a significant distance in a short period of time. Even troops on foot moving at 3.1 mph can move up to 416 meters in 10 minutes.

Speed (mph)	Speed (km Hr)	Time (min)	Distance (m)
3.1	5	5	416.7
3.1	5	10	833.3
6.3	10	5	833.3
6.3	10	10	1,666.7
9.4	15	5	1,250.0
9.4	15	10	2,500.0
15.6	25	5	2,083.3
15.6	25	10	4,166.7
25.0	40	5	3,333.3
25.0	40	10	6,666.7
37.5	60	5	5,000.0
37.5	60	10	10,000.0

Table A-6: Movement of land forces by speed and time

Table A-6 developed by the author shows how even slow movement of less than 15 kilometers per hour can result in movements in excess of 2000 meters within ten minutes – well outside of the lethal area of the smaller ordnance such as 5-inch guns – and hence the requirement to fire many rounds to achieve the desired effect. Movement under conditions of poor visibility, conditions exacerbated by poor weather or battlefield obscurants (to include jamming of projectile guidance receivers) can make it difficult for precision guided munitions to hit the target due to potential for high Target Location Error (TLE). The problems hitting moving targets are discussed in Rhodes's document; however, no quantitative analysis is provided. In a combat situation a volume fire mission can address this kind of threat.

Another problem with extended response times is the effect of enemy fire upon friendly forces over time. This is not addressed in the requirements document.

Rhodes stresses points initially made in Van Riper's initial requirements document. Interoperability, ability to execute counter battery fires, volume fires, and ensuring the NSFS are able to meet current minimum field artillery requirements

standards for accuracy, volume fires, and lethality. New to the document is the emphasis on multiple sources of NSFS. [372] This emphasis on multiple sources will grow and is seen in the current emphasis on "joint fires" which clouds identification of the source of fires, and which systems are most effective in a given situation.

The most recent USMC requirements document, issued by Lieutenant General Edward Hanlon in 2002, provides much greater fidelity than the previous two documents. It states the requirements outlined in Rhodes's memo remain valid. Of added significance the cover letter states up front that after six years and two requirements documents, the USMC felt it needed to issue a third document to "emphasize and further clarify" the NSFS requirement.[373]

The purpose statement of Hanlon's attachment references the 1993 NSFS Cost and Operational effectiveness Analysis (COEA) by stating "the naval service's requirements for a mix of naval guns and land attack missiles for NSFS have not changed." This statement was made a full 9 years after the COEA was published.[374]

Enclosure 1 for Hanlon's letter is over twice the size of the previous two USMC requirements documents. Of its 24 pages, nearly 5 of them are devoted to volume fires.[375] Various types and approaches to volume fire are outlined, to include suppression and neutralization of enemy capabilities.[376] To ensure volume from shipboard systems, the basic requirement per ship is set to mirror the volume capabilities of an artillery battery. This requires more than one 5-inch/54 caliber gun.[377] The only ship today that

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[372] USMC, *MCCDC 1996 NSFS Requirements for OMFTS*. 2.
[373] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, 1.
[374] Ibid., Encl. 1, 1.
[375] Ibid., Encl. 1, 13-17.
[376] Ibid., Encl. 1, 15-16. While no specific numbers are provided to directly create a battlefield effect, rates of fire are identified and are not far off from those identified by Vector Research and their Suppression Effects Study. See David Thompson.
[377] Ibid., 17.

mounts two such guns is a guided missile cruiser.[378] The fact that a single destroyer currently falls short of the volume (rate) of fire capability of an artillery battery is specifically identified in Hanlon's document. Also of significance, the capability to provide effective counter-battery fire and/or effective Suppression of Enemy Air Defenses are cited as critical to ensure friendly systems have the freedom to deliver fires over an extended period of time. [379] It is of significance that the latest Chinese destroyer class has two 130mm twin-gun turrets which contain three more guns than U.S. destroyers currently mount.[380]

A target categories matrix is included, yet noticeably lacks field fortifications, bunkers, tunnels, caves and other hard fixed targets that would require reduction in a littoral conflict. This may be due to a realization amongst Marine requirements officers that guns postulated by the Navy completely lack the hard target capability of the larger (8-inch and above) guns of the past. Israel's recent experience in Lebanon, as well as experience in World War II, Korea and Vietnam, should be instructive: Naval Fires must be capable of reducing these types of fortifications.[381] The absence of these types of targets from the target matrix is significant and the weapons that will address these very real target sets are unidentified.

Sustainment of naval surface fires systems is cited in Hanlon's memo as being defined by Admiral Mullen in Sept 2000 as, "Replenishment at Sea equals sustainment." While magazine capacity is not directly addressed, the Hanlon memo statement

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[378] *Marine Corps Warfighting Publication (MCWP) 3-16, Fire Support Coordination in the Ground Combat Element*, O-3.

[379] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Encl 1, 13-17.

[380] See http://www.globalsecurity.org/military/world/china/haizhou-specs.htm for additional information on the Chinese Haizhou Type 956 class Sovremenny destroyer.

[381] Many specific details on destruction of bunkers and tunnels with soldiers and Marines noting how effective major caliber shells were against such targets as opposed to 8-inch, 5-inch and 155mm guns. This lethality construct has not changed appreciably to this day. See the following. Dodd, Mark, "Iranian hand seen in tunnel network," *The Australian* (All-round Country Edition), 26 July 2006, sec WORLD, p. 8; Ellingwood, Ken, "Israel Finds 9 Tunnels from Gaza Strip into Egypt," *Los Angels Times*, Part A, p. 5; Riley, 45, 54, 128, 131-133, 193-200;

"innovative ways to re-supply to maintain continuous fire support, whether while the ship is on station firing or to minimize the time off station, must be studied" indicates the Marines are concerned about small magazine size.[382] In fact, the premise that a small magazine capacity and replenishment at sea while continuing to deliver fires during a fight is questionable at best. This concern is in keeping with the known small magazine capacities relative to the size of their guns for both DDG-1000 and the present DDG's and CG's in the fleet. One option is to increase the number of ships available to make up for a small magazine size. However, the Navy reduced the number of DDG-1000 platforms from 32 to 7.[383] The small magazine capacity is not congruent with history.

Overall cost of NSFS weapons and munitions are discussed within the same paragraph as "sustainment" and magazine capacities to make the point that naval forces must enter the fight with sufficient munitions to meet operational needs.[384]

	OMFTS 2015 MAA	**Volume of Fire Study**	**NSFS Requirements and Capabilities Study**	**21st Century SCFLS-Assessing the Impact of Evolving Missions on the Surface Combatant Force**
Source	MCCDC	NSWC, Dahlgren	JHU-APL	NSWC, Dahlgren
Scenario	SWA	NEA	NEA	NEA
Basis	6814 rds/6 days	5394 rds/19 hours	18,000 rds/17 hours	314,300 rds/65 days
Daily Assault rate	1,136	2,697	9,000	N/A
Daily Sustained Rate	251	596	1,988	N/A
30-day assault	34,080	80,910	270,000	N/A
60-day sustained	15,060	35,760	119,280	N/A
10 day SSC (sustained rate)	2,510	5,960	19,880	N/A
Totals	52,650	122,630	409,160	314,300

Table A-7: Extrapolated results from LTG Hanlon's NSFS Small Scale Contingency Studies [385]

[382] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Enclosure 1, 21; *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 21-22. LTG Hanlon's concern with sustainment is clear in this section of his document, and proves to be well founded as the Navy reduced the size of the magazines on DDG-1000 from 900 rounds to 600.

[383] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 17-18.

[384] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Encl 1, 22.

[385] Ibid., Encl 1, 22.

An indication of just how many projectiles may be needed is graphically shown in Table A-7 above. The munitions addressed in these four studies are gun based long-range precision-guided projectiles.[386] This does not address munitions delivered from air or missile systems. Three of the four scenarios are set in Northeast Asia (NEA), and they require considerably more projectiles than the single Southwest Asia (SWA) scenario. The last scenario in the chart above calls for roughly the same number of projectiles as the *2003 Concept of Operations for Land Attack Warfare* published one year after Hanlon's document.[387] The expected (as of 2003) purchase rate of ERM projectiles is 300 per year beginning in FY06.[388] The procurement rate of 300 projectiles per year will take about 266 years to purchase 79,000 projectiles. At $54,000 each, the cost is $10.8 billion for 200,000 projectiles.[389] At $10,000 each, 200,000 cost $2 billion. An important question is can a larger projectile reduce the overall number of projectiles required? This was not asked in any documents reviewed by the author. The CNA COEA stated that cost always decreases with increasing caliber, due mostly to greater lethality of the larger projectiles.[390]

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[386] Ibid., Encl 1, 22.

[387] Navy. *Concept of Operations for Surface Combatant Land Attack Warfare 2005-2015*. 8-7. Approximately 300,000 rounds over 60 days.

[388] Ibid., B10.

[389] The unit cost of an ERM projectile is estimated as high as $54,000 each.; Doran interview. A mix of major and minor caliber projectiles greatly reduces the overall cost due to the effectiveness of the larger bullets. See *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 11. Based on 1999 Navy estimates for new 16-inch shell bodies, one can assume a ball park cost for a 280mm sabot would be $8000, and the precision guidance kit an additional $3,500 for a total cost of $11,500 each. See U.S. Government Accountability Office. *FORCE STRUCTURE: Navy is Complying with Battleship Readiness Requirements* (Washington, DC: GPO, 14 April 1999), 6.

[390] CNA, *NSFS COEA*, 121.

			Near-term	Mid-term	Far-term
System Response		Threashold	2.5 minutes	2.5 minutes	2.5 minutes
		Objective	Limits of Technology	Limits of Technology	Limits of Technology
Range	Naval Guns	Threashold	41 nautical miles	63 nm	97 nm
		Objective	63 nautical miles	97 nm	Limits of Technology
	Other NSFS Systems	Threashold	200 nautical miles	200 nm	262 nm
		Objective	222 nautical miles	222 nm	Limits of Technology
Accuracy & precision		Threashold	50 CEP	50 CEP	50 CEP
		Objective	20 CEP	20 CEP	20 CEP
Target Acquisition		Threashold	50 nm	63 nm	97 nm
		Objective	63 nm	97 nm	Limits of Technology
Ordnance Effects	No specific naval gun ammunition types priorities or percentage of magazines are indicated Development and fielding of NSFS systems should focus on warhead and operatonal effects		* Destroy/neuteralize/suppress area targets (personnel/material) * Destroy/neuteralize/suppress moving targets * Destroy moving targets (with terminal seeker) * Destroy high payoff, point targets * Destroy hardened targets * Mark targets for battlefield observation * Provide obscuration (prevent enemy observation of friendly forces or own forces) * Set fires to enemy material and facilities * Illuminate battlefield at night * Mark targets for battlefield observation during period of reduced visibility		
Volume Fire			* Volumne equally important to precision * Massed fires * Suppression * Combined arms effects * Close fire support * Sufficient quantities are maintained to sustian desired effects over time		
Sustainment			* All systems must be sustainable via UNREP		

Table A-8: LTG Hanlon's Requirements for Naval Surface Fire Support [391]

The significance of this matrix is that it provides a single source overview of Marine Corps requirements for NSFS. This chart is specifically reproduced in the 2006 GAO report and the Navy is cited as agreeing upon these as the valid USMC requirements.[392] Much of the document is quantitative in nature. However, hardened targets have no further specificity and volume fires lack a quantitative definition. Range requirements remain the same as earlier documents.

[391] USMC, *MCCDC 2002 NSFS Requirements for Expeditionary Warfare*, Encl 2.
[392] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 10.

Appendix D:
The Joint Capabilities Integration and Development System (JCIDS)

This appendix provides background material on how the military services relate to the joint requirements process. Military services are responsible for developing tactics, techniques, procedures, and equipment to execute their missions. This responsibility is currently outlined in Title 10, United States Code, and is further defined in Department of Defense Instructions.[393] Title 10, Section 5013 directs the Secretary of the Navy to train and equip forces to "fulfill the current and future operational requirements of the unified and specified combatant commands."[394] The authority of the services in deciding how to meet requirements is reinforced within joint publications and the Joint Operation Planning and Execution System (JOPES).[395] For amphibious operations (a strategy or "way"), the United States Marine Corps shall "develop in coordination with the other Military Services, the doctrines, tactics, techniques and equipment employed by the landing forces in amphibious operations."[396] Likewise, the Navy is required, in coordination with the other Services, to "develop the doctrine, procedures and equipment of naval forces for amphibious operations and the doctrines, and procedures for joint amphibious operations."[397] The land forces (U.S. Army and Marine Corps) in littoral forced entry operations are the customers of the other services when fire support (a tool or "means") is required. Aside from specific tactics, doctrine and equipment for the

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[393] Department of Defense, *Department of Defense Directive 5100.1: Functions of the Department of Defense and Its Major Components* (Washington, DC: Department of Defense, 1 August 2002), 15-26.
[394] Title 10, Section 5013, accessed on 20 December 2006 at http://uscode.house.gov/uscode-cgi/fastweb.exe?getdoc+uscview+t09t12+2246+120++%28equip%29%20%20AND%20%28%2810%29%20ADJ%20USC%29%3ACITE%20%20%20%20%20%20%20%20%20%20. Each service secretary and the Secretary of Defense have their own enabling sections in Title 10.
[395] "The Services recruit, organize, train, equip, and provide forces for assignment to combatant commands." See U.S. Joint Chiefs of Staff, *Joint Publication 5-0; Doctrine for Planning Joint Operations*. (Washington: GPO, 13 April 1995), 1-1, V-1, V-2. U.S. Joint Chiefs of Staff, *Joint Publication 5-0; Joint Operation Planning*. (Washington: GPO, 26 December 2006), 1-4. This update to the first document states "The Services recruit, organize, train, equip, and provide forces for assignment to combatant commands and administer and support these forces."
[396] *Department of Defense Directive 5100.1: Functions of the Department of Defense and Its Major Components*, 20.
[397] Ibid., 20-21.

landing forces, the primary responsibility for NSFS rests with the Navy for amphibious and littoral operations.

Joint Requirements Integration: Title 10, sections 153, 163 and 181 show Congress's intent for greater joint integration.[398] Within these sections, the responsibilities of the Chairman, Joint Chiefs of Staff are outlined with respect to joint requirements, and in section 181, the Secretary of Defense is directed to establish the Joint Requirements Oversight Council (JROC). This section was added to Title 10 in 1996. The JCIDS process is the manner in which the intent of the JROC statutory requirement is executed. A quick review of Section 181 clearly shows congressional intent that the Chairman be assisted by the JROC "*in identifying and assessing the priority of joint military requirements (including existing systems and equipment) to meet the national military strategy*."[399] The statute directs the Chairman provide reports to the various congressional committees on the actions and recommendations of the JROC.

The charter of the JROC specifies its members to be General Officers of the Army, Air Force, Navy and Marine Corps, with the functional chairman being the Vice Chairman of the Joint Chiefs of Staff.[400] The focus of the JROC is acquisition monitoring and oversight to provide joint balance to service acquisition decisions and programs. For this analysis, the most significant of the 27 functions listed in the JROC charter is number 13, outlined below:

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[398] Joint Chiefs Of Staff; Chairman: functions, 10 USC, Sec. 153 (3 February 2005); Combatant Commands; Role of Chairman of Joint Chiefs of Staff, 10 USC, Sec. 163 (3 February 2005); Boards, Councils; And Committees: Joint Requirements Oversight Council, 10 USC, Sec. 181 (3 February 2005), All accessed 8 November 2006 at http://uscode.house.gov/uscode

[399] Title 10, Section 181, accessed 20 December 2006 at http://uscode.house.gov/uscode-cgi/fastweb.exe?getdoc+uscview+t09t12+132+0++%28%29%20%20AND%20%28%2810%29%20ADJ%20USC%29%3ACITE%20AND%20%28USC%20w%2F10%20%28181%29%29%3ACITE%20%20%20%20%20%20%20%20%20%20.

[400] U.S. Joint Chiefs of Staff. *Chairman of the Joint Chiefs of Staff Instruction 5123.01B. Charter of the Joint Requirements Oversight Council* (Washington, DC: Joint Chiefs of Staff, 15 April 2004), A-2.

> Ensure Service-proposed capabilities, forces, programs and budgets are linked to the national military and defense strategies, SPG, joint operations concepts and integrated architectures (when or as developed) and COCOM-identified capabilities needed.[401]

Within the other specified tasks, the JROC is required to assess the cost, schedule and performance of major acquisition programs, assign joint priority to existing and future acquisition programs designated to meet valid capabilities, and ensure they conform to and reflect the resource (means) levels projected by the Secretary of Defense through the Joint Programming Guidance.[402] JROC decisions are intended to directly impact service programs and decisions on equipment acquisition. By extension, it appears logical that the JROC would look for the most cost effective solutions to fill joint requirements capabilities gaps.

Role of the Combatant Commands: Each of the Combatant Commands (COCOM) has "a standing invitation to attend JROC sessions in an advisory role to the JROC Chairman on joint issues that address present and/or future joint Warfighting capabilities."[403] The JROC charter specifies that COCOMS will have a direct communication line with the JROC and acquisition decision authorities.[404] This direct line is designed to ensure the needs of COCOMs are heard by the JROC in a timely manner. COCOM staffs plan for future contingencies using existing or programmed assets outlined in the Joint Strategic Capabilities Plan (JSCP).[405] Mike Fitzgerald stated:

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[401] Ibid., A-6. The SPG is the Strategic Planning Guidance, which is issued by the Department of Defense to the services at the start of each Planning, Programming and Budgeting cycle.

[402] Ibid., A-1.

[403] Ibid., A-2.

[404] Ibid., A-12.

[405] Chairman, Joint Chiefs of Staff. *CJCSM 3122.01A: Joint Operation Planning and Execution System (JOPES).* (Washington, DC: Department of Defense, 29 Sept 2006), C-3. This document states that JSCP, Contingency Planning Guidance, Global Force Management Guidance and other Combatant Commander planning guidance are all based upon military capabilities (forces) resulting from completed program and budget actions available for planning. This means forces and equipment not programmed or budgeted are generally not available for planning and therefore would not normally receive any degree of staff analysis by the Combatant Commander's staff.

> "The COCOM staffs have very limited capacity to engage in the Functional Capability Boards (FCB's) and the JCIDS process proper. This situation is exacerbated when conducting contingency operations."[406]

It is difficult to see how COCOM staffs can influence the JCIDS process unless they can conduct analysis beyond the scope of the current force.

Joint Requirements Development Process: The Chairman of the Joint Chiefs of Staff publishes guidance and instructions on the conduct of the JROC and the supporting JCIDS process.[407] This top driven process is managed by the Director, Joint Staff and the J-8. The overall management is provided by Joint Capabilities Board (JCB).[408] The JCB then assigns issues to the appropriate Functional Capabilities Board (FCB).[409]

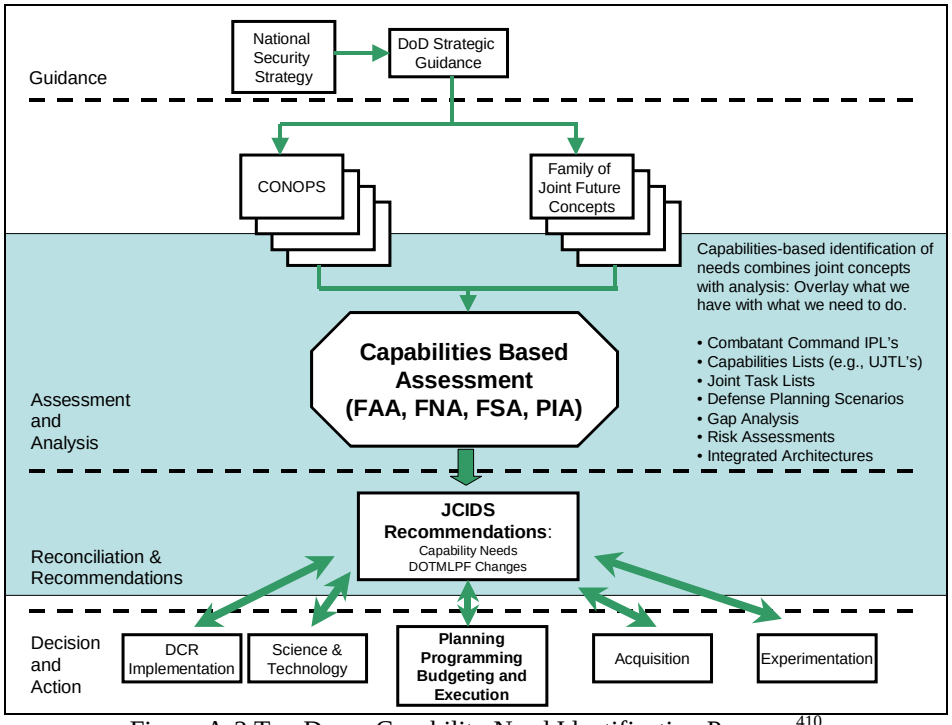

Figure A-2 Top Down Capability Need Identification Process [410]

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[406] Interview, COL (ret) Mike Fitzgerald, 6 Feb 2006. COL Fitzgerald was the key planner on the Central Command staff for Operations Enduring Freedom and Iraqi Freedom.

[407] U.S. Joint Chiefs of Staff, *Chairman of the Joint Chiefs of Staff Instruction 3170.01E. Joint Capabilities Integration and Development System*. (Washington: Joint Chiefs of Staff, 11 May 2005).

[408] Ibid., A3, GL-6; *Charter Of The Joint Requirements Oversight Council*, A-9.

[409] *Chairman of the Joint Chiefs of Staff Instruction 3170.01E. Joint Capabilities Integration and Development System*, A-6.

[410] Ibid., A-4.

The key analytic underpinning of the process is a series of Capabilities Based Assessments (CBA) as shown in the Figure A-2 above. These CBA are the Functional Area Analysis (FAA), the Functional Needs Analysis (FNA), the Functional Solution Analysis (FSA), and the Post Independent Analysis (PIA). This process begins by identifying the operational tasks, conditions and standards needed to achieve military objectives (FAA). The next analysis compares all current and programmed Warfighting systems (capabilities) against the capabilities required to determine what gaps exist in the required capabilities at a given date in the future, usually ten years (FNA). The identified gaps are the key start point for the next analysis which is an operationally based assessment of all potential DOTMLPF (Doctrine, Organization, Training, Material, Leadership and Education, Personnel and Facilities) solutions that can close the previously identified gaps. This analysis is then subjected to an independent review by a non-biased third party (the PIA) to ensure all processes and resulting recommendations are reasonable and that appropriate diligence was exercised.

All of this analysis serves as the basis for the decision to develop an Initial Capabilities Document (ICD) which is the formal start point for developing a long term procurement solution to the identified capabilities gaps. The ICD is the first formal product of the JCIDS process that is presented to the JROC. When approved it initiates actions to satisfy the capabilities gaps identified in the functional analysis process.[411]

The JCIDS process is time consuming and deliberate. It is designed to get all service acquisition programs aligned and prevent duplication of capabilities. The final list of "capabilities gaps" is the most important product of the ICD analysis and serves as the start point from which additional steps are taken to determine the best way to close these identified gaps. The remaining steps to IOC (Initial Operating Capability) are

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[411] Ibid., A-3 to A-6.

outlined in the chart below. This process is normally measured in years from the start of analysis to IOC.[412]

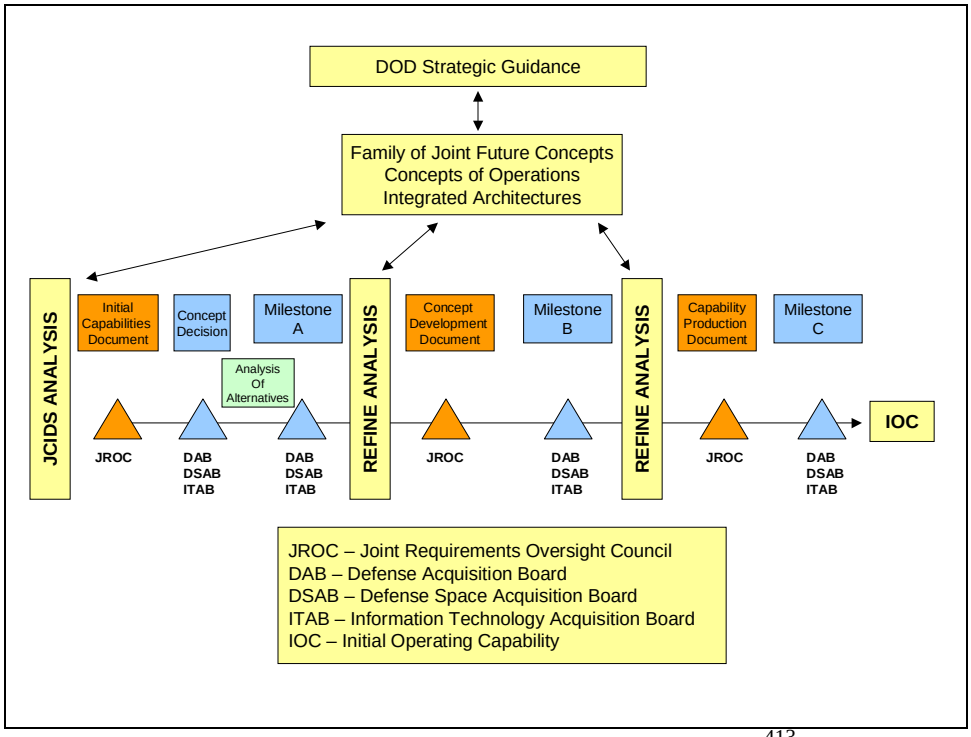

Figure A-3: JCIDS Process and Acquisition Decisions [413]

NSFS enters the joint requirements process: On 23 July 2004, the Marine Corps Combat Development Command received Joint Staff J8 concurrence that an Initial Capabilities Document was required.[414] In December 2005, the JROC approved the Initial Capabilities Document (ICD) for "Joint Fires in Support of Expeditionary Operations in the Littorals."[415]

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[412] Interview, LtCdr Bryan Clark, 16 January 2007. Times for achieving IOC are highly variable. Typical time to get to a Capabilities Development Document, which is Milestone B, is about one year. The Joint Fires in support of Expeditionary Operations in the Littorals took about 18 months to get to Milestone A, the ICD. Together that is almost three years.

[413] *Chairman of the Joint Chiefs of Staff Instruction 3170.01E. Joint Capabilities Integration and Development System*. A-8.

[414] Interview, LTC Brad Herndon, 18 August 2006. During this interview a briefing and associated documents provided the Marine Corps timeline and identified the J8 approval date. Marine Corps Combat Development Command, "*Joint Fires in Support of Expeditionary Operations in the Littorals – Initial Capabilities Document*," Sept 2004.

[415] *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 9.

Appendix E:
Additional Cost Analysis Information

In addition to the operations and support costs outlined in Chapter 7, two other major cost categories apply to the recommendations at the conclusion of the study in Chapter 8. These are acquisition costs for ships and aircraft. Munitions are also a major cost driver and large precision munitions such as Tomahawk and Joint Stand-off Weapon (JSOW) are considerably more expensive than gun launched precision munitions. Personnel costs are part of operations and support costs cited in Chapter 7.

Ship construction and alteration costs have been brought to FY2007 constant dollars. Munitions costs are more difficult and should be regarded as estimates only unless they came from a specific authoritative document cited in the footnotes. These costs are for general consideration and require additional refinement for programming.

Aircraft	Cost per ($M)	# Aircraft	Total Cost ($M)
F/A 18E/F Hornet	$79	40	$3,163
E-2C Hawkeye	$351	4	$1,406
E/A 18G Growler	$106	4	$426
H-60 helecopter (upgrades)	$40	6	$239
	Total =	54	$5,233

Table A-9: FY2007 Air Wing acquisition cost (minus auxiliary aircraft) in millions of dollars[416]

The overall cost of an air wing is considerably more than most surface warships and is almost half the cost of the aircraft carrier ship platform alone. According to the GAO, the E/A-18 Growler and the E-2C Hawkeye have suffered cost increases due to immature technologies.[417] Aircraft acquisition is typically a 2-year process from start of production to roll out from the factory floor. [418] Design is generally much longer, with the F22A Raptor Fighter taking almost 19 years from program decision in 1986 to Initial

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[416] U.S. Department of Defense Comptroller, *Program Acquisition Costs By Weapon System, Fiscal Year 2007* (Washington, DC: GPO, February 2006), 6, 8, 9, 12.
[417] U.S. Government Accountability Office, *DEFENSE ACQUISITIONS: Assessments of Selected Major Weapon Programs* (Washington, DC: GPO, March 2005), 51-54.
[418] U.S. Government Accountability Office, *DEFENSE ACQUISITIONS: Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs* (Washington, DC: GPO, February 2005), 5.

Operating Capability in 2005.[419] Acquiring additional air wings is a significant financial investment over time in addition to the costs associated with aircraft life cycle maintenance and replacement due to fatigue or combat loss.

New ship construction can be even more difficult to cost as their lead research, development (R&D) and acquisition costs spread over several years. The next generation aircraft carrier and the DDG-1000 are good examples of this funding flow.

Single Ship	FY05	FY06	FY07	FY08	Cumulative Cost ($M)
CVN-78 / lead cost CVN-79	$973	$1,063	$1,107	$3,081	$6,224
DDG-1000 (formerly DD(X))	$717	$893	$1,681	$1,728	$5,020

Table A-10: Ship Research, Development and Construction Costs[420]

Ship costs above show the single cost lead and procurement costs as documented in the fiscal year 2007 and 2008 budget submissions to congress. DDG-1000 research and development cost is in FY05 and FY06, and construction costs are FY07 and FY08. The CVN-21 construction is in FY08 with all the other costs being R&D and preparation. The overall costs cited by the Navy to construct the CVN-21 class ship is $3.2 billion for development and $10.5 billion for construction for a total cost of $13.7 billon overall.[421] Originally in 1997, DDG-1000 (then DD-21) was to cost $921 million per ship and be operational by FY2008.[422] By 2005 the unit cost had risen to $3.1 billion per ship.[423] Congress directed Navy that it could spend no more than $3.26 billion apiece for the first two ships.[424] The rise in cost is due mostly to changes in the design and lack of maturity

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419 *DEFENSE ACQUISITIONS: Assessments of Selected Major Weapon Programs* (March 2006), 59.
420 U.S. Department of Defense Comptroller, *Program Acquisition Costs By Weapon System, Fiscal Year 2007* (Washington, DC: GPO, February 2006), 41, 42; *Program Acquisition Costs By Weapon System, Fiscal Year 2008*, 47, 48. The FY05 data is from the FY2007 cost book.
421 Congressional Research Service, *Navy CVN-21 Aircraft Carrier Program: Background and Issues for Congress.* Washington, DC: Library of Congress, 24 June 2005), CRS-2.
422 *Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, 19.
423 Ibid., 20.
424 Ibid.

of almost all new critical technologies involved.[425] Add the cost of an air wing, at roughly $5.2 billion, plus the cost of the CVN, at approximately $13.7 billion, and the total cost of acquisition of a CVN and its air wing exceeds $18 billion in acquisition.

Ship Type	Unit cost	Total Ships	Total Cost	% of 4 CSW
CVN-21	$13.7	5	$61.7	154.1%
CVN-21 w/air wing	$18.9	5	$85.2	213.0%
DDG-1000	$3.4	32	$97.9	244.8%
DDG-1000	$3.4	24	$73.4	183.6%
DDG-1000	$3.4	7	$21.4	53.6%
Wpns (com hull)	$4.0	4	$14.4	36.0%
CSW	$10.0	4	$40.0	N/A
BB modernization	$1.4	2	$2.7	12.8%

Table A-11: Construction cost ($ Billions) comparison in FY07 constant dollars[426]

The Navy's 2007 30 year shipbuilding plan identifies five CVN's being commissioned between FY08 and FY25 when the near-peer competitor is likely to appear.[427] In 2019 a twelfth CVN will be added to the active fleet. Given the similar firepower and additional capabilities, consideration to substituting two CSW for one CVN in the 2010 to 2020 construction time period will save money and grow additional and unique capability for the Joint Force Commander.

The CSW is approximately four times the size of the DDG-1000. Based upon the cost the DDG-1000 and likely design similarities applicable to a CSW, it is reasonable to assume design and construction cost for such a warship would be similar but scaled upwards to approximately $10 billion dollars per ship. This is partially based upon a 350% increase in size. Construction cost estimate for CSW is a very rough comparison of complexity and displacement between the CVN-21, DDG-51, DDG-1000 and LPD-17.

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[425] Ibid., 19-22; *DEFENSE ACQUISITIONS: Assessments of Selected Major Weapon Programs* (March 2006), 47-48.

[426] *Program Acquisition Costs By Weapon System, Fiscal Year 2008*, 48. Cost for DDG-1000 is based upon FY07 appropriation and the FY08 request as reflected in the document and then divided for two ships. This cost includes research and development costs that are likely outside of the congressional construction cap for the two ships. The acquisition cost of an air wing is explained in Table A9. For battleship modernization costs see *Battleships: United States Battleships, 1935-1992*, 260-261. Costs reflected in the table above are Inflated to 2007 constant dollars. The inflation formula was accessed on 12 March 2007 at http://www.ncca.navy.mil/services/inflation.cfm.

[427] *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2007*, 6.

The $10 billion cost assumes approximately $12 billion total research and development (R&D) for all four ships. The R&D cost is assumed to also include the major caliber guns associated with the ship. Using proven technologies as opposed to cutting edge technologies on selected systems should keep costs down or even lower them below trends established for DDG-1000 cost growth.

Building the 32 DDG-1000s initially requested by the Navy is approximately 244% of the cost of building four new CSWs. This is assuming a 10% overall reduction in the cost of DDG-1000 from the current programmed cost. Twenty-four DDG-1000 as identified by the Marines as required for NSFS cost about the same as six CSW. Since the firepower of a CSW is more than four times that of a single DDG-1000, having a mix of ships is considerably more effective in light of a near-peer competitor than building more DDG-1000's at greater cost.

The construction cost for the weapons or fire support ship is assumed to be about twice that of a DDG-51 or about $4 billion. As no formal cost estimates were provided in the related congressional report, a more realistic estimate is not possible in this study.

Cost overruns and changes in cost projections are a potential stumbling block to fielding the CSW's prior to the appearance of a near-pear competitor or a regional competitor with robust anti-access capabilities. A number of reports and studies deal with the volatility of the programmed costs for major defense acquisitions such as ship construction. Recent reports such as the GAO report on long-range shipbuilding identify systemic and serious stability problems within Navy shipbuilding that are multifaceted and pose significant risk to timely construction.[428] The RAND Corporation completed another such study in 1993 under the sponsorship of the Undersecretary of Defense for

[428] U.S. Government Accountability Office, *DEFENSE ACQUISITIONS: Challenges Associated with the Navy's Long-Range Shipbuilding Plan* (Washington, DC: GPO, March 2006).

Acquisition and Technology, entitled "An Analysis of Weapon System Acquisition Schedules" which provides additional information related to cost overrun potential.[429]

Cost of munitions is another aspect of comparison of an NSFS focused CSW and a CVN. The chart below is a hypothetical loading of an aircraft carrier to demonstrate the overall cost of a munitions load. The aviation ordnance identified in the chart is a purely hypothetical mixture of weapons designed to show an average cost of the load for one aircraft carrier. The mixture of the types of munitions identified above would be different for each operation the carrier was deployed to support.[430] Requirements for standoff greatly increase costs.

Nuclear Aircraft Carrier Hypothetical Load ($K)				
Purpose	**Weapon**	**Number**	**Unit Cost**	**Total Cost**
	Hellfire	64	$100	$6,400
AA	Rockey (FMU-140)	30	$10	$300
A	JSOW A	55	$219	$12,045
P	JSOW C	10	$237	$2,370
GP	JDAM (BLU-111)	650	$26	$16,871
GP	JDAM (BLU-110)	300	$29	$8,658
GP	JDAM (BLU-117)	20	$34	$681
P	JDAM (BLU-109)	30	$43	$1,286
Anti-Radar	HARM (Block C)	100	$360	$36,000
SPP	SLAM ER	20	$619	$12,380
DAPP	Laser Maverick	25	$180	$4,500
GP	LGB (BLU-111)	950	$24	$23,107
GP	LGB (BLU-110)	30	$14	$419
GP	LGB (BLU-117)	20	$22	$441
P	GBU-24 B/B (BLU-109)	30	$89	$2,682
DP	GBU-24 G/B (BLU-116)	20	$174	$3,484
			Total Cost =	***$131,622***

Table A-12: Hypothetical munitions cost ($ thousands) for a CVN.[431]

[429] Jeffrey A. Drezner and Giles K. Smith, *An Analysis of Weapon System Acquisition Schedules* (Santa Monica, CA: RAND Corporation, 1990).

[430] Interview, Jack Sterling, 13 February 2007.

[431] Cost data for these munitions was provided by Christopher. J. "Saint" St. George, Senior Munitions Analyst, NNOR Assessments Division, OPNAV N81TG at Headquarters, Department of the Navy, Washington D.C. and Mr. Jack Sterling, Fleet Forces Command, N805C, Norfolk, Virginia between 1-13 February, 2007. Mr. Sterling provided the hypothetical aircraft carrier load to ensure a balanced approach to cost. The costs provided by Mr. St. George are individual weapon acquisition costs and do not include tooling, research and development or other ancillary costs as included in the Office of Secretary of Defense Cost handbook which is published each fiscal year.

Gun munitions for a hypothetical CSW are identified in the chart below. The major cost driver is the Tactical Tomahawk missile, the major caliber scramjet, and the ERM "like" munition. Without the Tomahawk included, costs are about $100 million and provide an indication that most gun based munitions, even when precision guided, are significantly less costly than procuring precision guided long range missiles such as the Tomahawk, SLAM-ER and the JSOW.

Capitol Surface Warship Hypothetical Load ($K)				
Purpose	**Weapon**	**Number**	**Unit Cost**	**Total Cost**
GP/DP	16-inch Standard & Ext. Range Sabot	1,000	$21	$21,000
GP/DP	16-inch Scramjet	300	$100	$30,000
A	5-inch standard	4,000	$2	$6,520
GP	5-inch ERM type munition	1,000	$45	$45,000
C	TACTOM Tomahawk	96	$739	$70,944
	Total Cost - Gun Munitions Only =			***$102,520***
			Total Cost =	***$173,464***

Table A-13: Hypothetical munitions load for a Capital Surface Warship.[432]

Purpose	**Description**
GP	General Purpose
P	Penetrator
DP	Deep Penetrator
DAPP	Direct Attack Precision Point
A	Area
AA	Area Plus Anti-Armor
C	Cruise Missile
SPP	Standoff Precision Point

Table A-14: Key to purpose column in Tables A-12 and A-13.

[432] The costs portrayed above are generally correct for fiscal year 2007 costs. This data is meant to show order of magnitude, not pinpoint budget accuracy. For the cost of a 16-inch conventional or sabot projectile, see *Navy is Complying with Battleship Readiness Requirements*, 6. GAO report provided cost for new shell bodies. Mr. Steve Kienzle, (VP Business Development, ATK Energetic Systems Division, Radford Army Ammunition Plant) provided a rough estimate of the cost for new 16-inch propellant in 2000 round lots for about $10 per pound or $11,700 per projectile; The cost for LRLAP and 16-inch advanced long range rounds are estimates based upon early costs for Excalibur and ERM costs. No reliable cost estimates for these projectiles are published; For the 5-inch Extended Range Munition cost, see U.S. Government Accountability Office. *DEFENSE ACQUISITIONS Challenges Remain in Developing Capabilities for Naval Surfaced Fire Support, GAO-07-115.* (Washington, DC: GPO, November 2006), 11; For the Tomahawk the cost is the direct procurement with no overhead or recurring costs according as provided by Mr. St. George on 9 March 2007; For the 5-inch all up round cost, see FY07 Navy Budget Submission available at http://www.finance.hq.navy.mil/fmb/07pres/books.htm for Navy and Marine Corps munitions procurement. Prior years are available at http://www.finance.hq.navy.mil/fmb/; The Precision Guidance Kit's Course Correcting Fuse was applied to all munitions. The cost goal for CCF is $3,500 each as provided by Mr. Russell Hill, Combat Ammunition Systems, Precision and SMART Systems, Picatinny Arsenal, *New Jersey*, on 11 March 2007.

The comparison in the table below provides greater fidelity to the cost of gun based munitions verses precision guided missiles. The precision guided bombs such as JDAM are roughly the same cost as gun based precision guided munitions and long range sabot precision guided munitions. This comparison is based upon the cost of the course correcting fuse. The extended range munitions such as ERM and LRLAP have rocket motors and are slightly more expensive than JDAM munitions. All however are considerably less costly than missiles.

Munition Type	Indv. Cost ($000)	Purchase 2,000	Purchase 10,000	Percent of Tomahawk
Tactical Tomahawk (~350 year)	$739	$1,478,000	$7,390,000	100%
JSOW - AGM-154	$237	$474,000	$2,370,000	32%
Small Diameter Bomb	$159	$317,349	$1,586,746	21%
5-inch all up round	$5	$10,208	$51,040	1%
5-inch Extended Range Munition	$54	$108,000	$540,000	7%
155mm XM982-U Excalibur (~191 yr)	$80	$160,000	$800,000	11%
16-inch all up round	$26	$52,800	$264,000	4%
155mm LRLAP	$75	$150,000	$750,000	10%
16-inch Extended Range Munition	$100	$200,000	$1,000,000	14%

Table A-15: Cost Comparison of Bombs, Missiles and Projectiles[433]

In overall considerations of cost, the most dramatic difference between these two capital ships is the operations and support costs. Construction is higher for the CVN; however, the disparity is much smaller than operations and support costs. Munitions costs diverge significantly when missiles are introduced, but precision ballistic projectiles and standard JDAM guided bombs is very similar. Based on the analysis conducted in this study, the gun based precision long range solution is often more cost effective than air delivered munitions, thereby offering significant complementary capability improvement to our already robust air based arsenal at far less cost.

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[433] The costs portrayed above are generally correct but due to inflation differences each of these costs are in then year dollars as reported in the their various sources. This data is meant to show order of magnitude, not pinpoint budget accuracy. For the Tomahawk and JSOW the cost is the direct procurement with no overhead or recurring costs according as provided by Mr. St. George on 9 March 2007; For Small Diameter Bomb costs, see FY2007 OSD Program Weapons Cost Book, accessed 20 Nov 2006 at www.dod.mil/comptroller/defbudget/fy**2007**/fy**2007**_weabook.pdf ; For 155mm Excalibur costs, see Army Budget submission for ammunition which was accessed 22 February 2007 at http://www.asafm.army.mil/budget/fybm/fybm.asp; for 5-inch, 16-inch and LRLAP costs, Ibid.

Appendix F:
FireSim XXI Detailed Results and Additional Scenarios

The following appendix contains additional background information and additional simulation output data detail than provided in Chapter 6.

The FireSim XXI modeling simulation system: In use for over two decades, this simulation models the target acquisition, communications, weapons/target allocation, and artillery firing in detail in a dynamic scenario. FireSim XXI may be executed in either DIS or closed analytical mode. FireSim XXI is a research and evaluation tool used primarily to analyze the relative differences between competing indirect fire systems, such as target acquisition sensors, automated tactical data systems, ammunition, and ammunition delivery platforms, within various arrangements of core structures. FireSim XXI also simulates air delivered ordnance. Since 1980, FireSim has supported 147 major studies and analyses. Since 1994, FireSim has supported 59 major experiments and training exercises. Most recently, FireSim XXI was used in Joint Forces Command's Urban Resolve Experiment.[434]

The OMFTS Scenario:[435] The forces are North Korean (Orange) and coalition (Blue). Orange opposition consists of approximately two corps of Military District Command (MDC) infantry, positioned along the coast in an anti-landing role. In addition, there are several battalions of light infantry protecting Inje and its' approaches. Finally, once the Blue Force landing is executed, it would be expected that enemy maneuver forces located further south near the battle area would react. Orange artillery and heavy

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[434] Interviews, LTC Chris Niederhauser and John Horn of the Fires Battle Lab at Ft. Sill Oklahoma, 22 November 2006 and 9 March 2007. Additional studies identified were the non-line of sight (NLOS) Cannon Caliber Decision Analysis, Counter-fire Radar Mix Analysis, Guided Unitary Analysis for TTP Development, Aiming Strategy Analysis for Guided Multiple Launch Rocket System (GMLRS) Dual Purpose Improved Conventional Munition (DPICM), Precision Guidance Kit (PGK) Analysis of Alternatives, Joint Fires Study, Enhanced AN/TPQ-36 OMS/MP and 105mm Precision Munition Requirement Analysis.

[435] All scenario information and overview provided by Sue Quensel, 15 March 2007 and reviewed by Dr. Alan Zimm on 23 March 2007.

brigades would be withdrawn from the southern offensive and would be employed against the OMFTS (amphibious and inserted) forces. In particular, Orange maneuver forces will counterattack against the road junction if the Blue forces are successful in taking Inje. The Orange forces remain the same through all phases. Figure A-4 shows the positioning of the Orange and Blue Forces at the beginning of the Scenario.

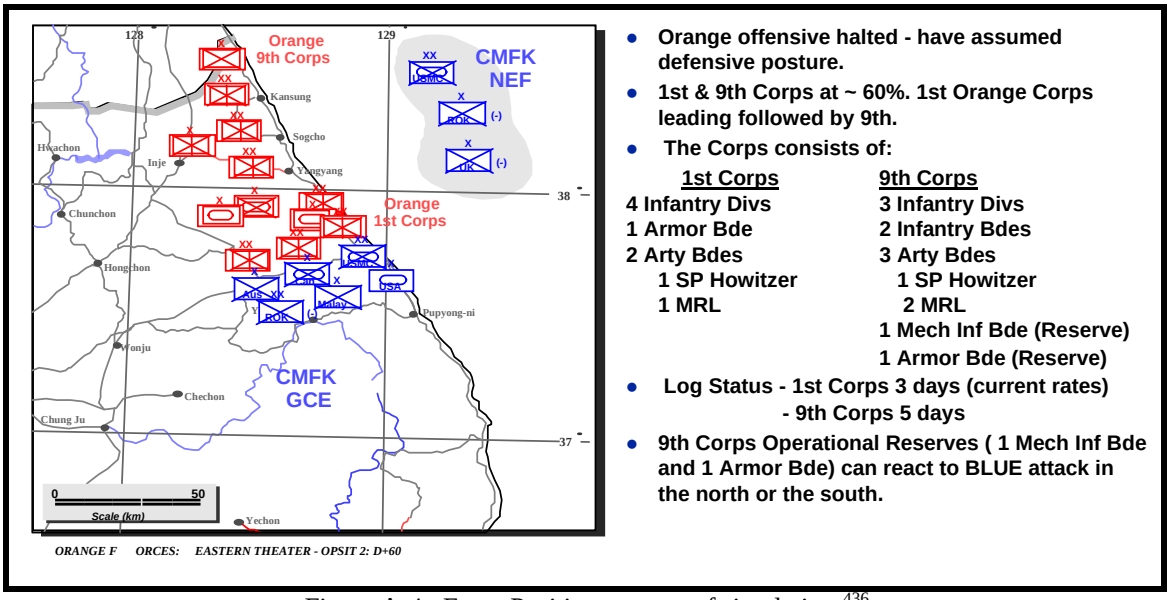

Figure A-4: Force Positions at start of simulation.[436]

The grid squares represent 20km Easting and Northing. The Orange forces are shown in Red with their MRL units in Purple. SCUD (tactical ballistic missile) units are located in the north with targets identified near Wonju approximately 110K to the south and in Seoul. Silkworm missiles are located along the coast within range of the ships. The Blue forces have positioned Special Forces at various locations throughout the area

As stated in Chapter 6, the scenario began 60 days prior to the start of this simulation and is a three-phased operation to trap the Orange forces that advanced south of the DMZ during the initial invasion. The Phase 1 tasks are the only ones modeled in this FireSimXXI vignette. These phase 1 tasks represent a 17-hour scenario. The additional phases are provided for clarity.

436 Ibid.

Phase 1 is a Sea-Air Assault. (D+60, 1900 hours) The Coalition Multi-National Force Korea (CMFK) executes vertical and surface assaults to destroy Orange 9th Corps and trap the withdrawing 1st Corps forces. This phase has four main tasks that are shown in Figure A-5 and described below.

a) Task A – Vertical Assault. A Blue (Republic of Korea) Marine Regiment is inserted to destroy the Orange Corps Artillery emplacements. In the North and West, their primary purpose is to locate the MRL units and prepare fire plans for execution. In the South, the teams have been placed along two road systems that lead to Inje. These teams will provide calls for fire as the armored brigade moves North to try and intercept the main Blue force as it approaches Inje. They are also to provide flank security for the main attack.

(1) In the north, well within range of the anticipated landing penetration zone for the amphibious assault, the primary threats are the 240mm and 122mm Multiple Rocket Launchers (MRL), along with some 122mm and 152mm artillery.

(2) The MRLs have the capability to ripple fire their ammunition load and displace from the firing point in minutes, making it nearly impossible to destroy by counter fire. The objective of this phase is to force the MRLs to displace, allowing them to be hunted down and destroyed by Blue air assets, particularly helicopters employing IR and night vision equipment

b) Task B – Vertical Assault and establishment of a blocking force by a reinforced USMC regiment on Highway 465. One battalion blocks the northern approaches while 2 battalions block the southern approaches.

c) Task C – Vertical Assault and establishment of a firebase along the road between the coast and Inje. Blue forces supported by Naval / Marine Air and Naval Surface Fires are inserted by V-22. They then establish a firebase of 155mm howitzer batteries.

d) Task D –Amphibious Assault: An USMC Division Regimental Landing Team (RLT) and a ROK Marine Regiment (-), conducts a beach landing.

e) Task E – Seize Crossroads – The RLT and the ROK Marine Regiment (-), after landing successfully, conduct an assault to seize the critical crossroads at Inje, thus blocking Orange escape routes north and trapping the 1st Orange Corps.

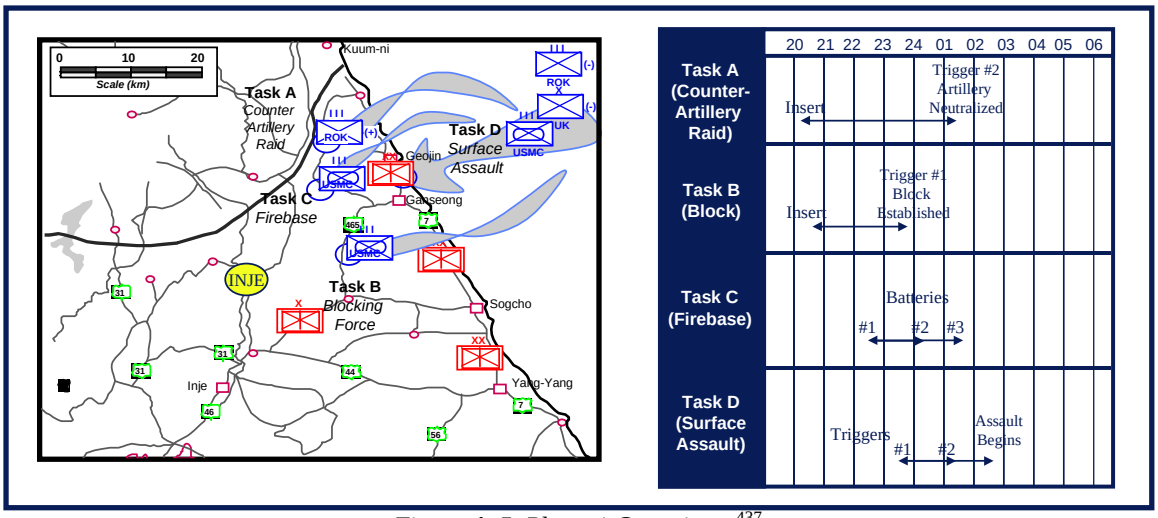

Figure A-5: Phase 1 Overview. [437]

Phase 2, which is not modeled, is a Ground Assault (D + 61, 0600) where the CMFK Ground Combat Element attacks north to drive Orange 1st Corps out of their prepared defenses and into the trap created by the deep insertion of NEF forces.

Phase 3, which also is not modeled, is an entrapment and link-up (NLT D + 62). CMFK Ground Combat Element and Naval Expeditionary Forces trap and neutralize Orange forces, and establish linkup in the vicinity of Ganseong.

The Phase 1 tasks are the only ones modeled in this FireSim XXI vignette. The discussion of the other phases has been included for clarity. The phase 1 tasks represent a 24-hour scenario.

The results in detail: In addition to the material in Chapter 6, the following tables provide greater detail of the simulation results. Each series of tables are presented with the archive simulation first and CSW simulation second. The data presented provides a full overview of the results of each simulation and enables the reader to do their own review of the performance of the various weapons and platforms.

437 Ibid.

	Range Bands in Meters			
Archive Simulation	**0 - 39**	**40 - 99**	**100 +**	**Total**
Sum of Total Kills	2,426	771	11	3,208
Sum of Veh Kills	234	83	2	319

Table A-16: Archive Simulation Total Kills by range band.

	Range Bands in Meters			
CSW Simulation	**0 - 39**	**40 - 99**	**100 +**	**Total**
Sum of Total Kills	2,911	1,219	66	4,196
Sum of Veh Kills	382	167	17	566

Table A-17: CSW Simulation Total Kills by range band.

The three tables below show the kills overall and by vehicle category in each of the two simulations. The third chart provides the difference between the two simulation's kills by number and percent. DDG-51 is replaced by the CSW.

Archive Simulation	**DDG-51**	**DDG-1000**	**Aviation**	**Artillery**	**EFSS (mortar)**	**Mortar**	**Grand Total**
All Kills	146	596	1,809	592	24	41	3,208
Vehicle kills	14	63	186	55	1	0	319

Table A-18: Archive simulation total kills by target category.

CSW Simulation	**CSW**	**DDG-1000**	**Aviation**	**Artillery**	**EFSS (mortar)**	**Mortar**	**Grand Total**
All Kills	1,739	468	1,674	273	13	29	4,196
Vehicle kills	301	37	199	29	0	0	566

Table A-19: CSW simulation total kills by target category.

CSW vs Archive Simulation results	**CSW vs DDG-51**	**DDG-1000**	**Aviation**	**Artillery**	**EFSS (mortar)**	**Mortar**	**Grand Total**
Total delta	1,593	-128	-135	-319	-11	-12	988
Vehicle delta	287	-26	13	-26	-1	0	247
Percent total delta	1191%	79%	93%	46%	54%	71%	131%
Percent Vehicle delta	2150%	59%	107%	53%	0%	0%	177%

Table A-20: Comparison of Kill percentage difference between the two simulations.

			Range (Kilometers)			
Platform	**Projectile**	**Category**	**0 - 39**	**40 - 99**	**100 +**	**Total**
DDG-51	ERM	Sum of Missions		9		9
	HE PD	Sum of Rounds Fired		20		20
		Average of Rounds Fired		***2.22***		***2.22***
		Min of Rounds Fired		1		1
		Max of Rounds Fired		12		12
		All Kills		3		3
		Vehicle Kills Only		0		0
	ERM	Sum of Missions	3	34	8	45
	HE VT	Sum of Rounds Fired	60	494	116	670
		Average of Rounds Fired	***20.00***	***14.53***	***14.50***	***14.89***
		Min of Rounds Fired	18	3	8	3
		Max of Rounds Fired	24	18	18	24
		All Kills	4	134	5	143
		Vehicle Kills Only	1	11	2	14
DDG-1000		Sum of Missions	33	416	21	470
		Sum of Rounds Fired	144	1610	96	1850
		Average of Rounds Fired	***4.36***	***3.87***	***4.57***	***3.94***
		Min of Rounds Fired	2	1	1	1
		Max of Rounds Fired	5	10	5	10
		All Kills	32	560	4	596
		Vehicle Kills Only	5	58	0	63
Artillery		Sum of Missions	69			69
		Sum of Rounds Fired	1398			1398
		Average of Rounds Fired	***20.26***			***20.26***
		Min of Rounds Fired	8			8
		Max of Rounds Fired	24			24
		All Kills	592			592
		Vehicle Kills Only	55			55
USMC Expeditionary		Sum of Missions	88			88
Fire Support System		Sum of Rounds Fired	960			960
(EFSS Mortar)		Average of Rounds Fired	***10.91***			***10.91***
		Min of Rounds Fired	3			3
		Max of Rounds Fired	30			30
		All Kills	24			24
		Vehicle Kills Only	1			1
Fixed Wing		Sum of Missions	476	16	1	493
		Sum of Rounds Fired	1934	38	4	1976
		Average of Rounds Fired	***4.06***	***2.38***	***4.00***	***4.01***
		Min of Rounds Fired	1	1	4	1
		Max of Rounds Fired	10	4	4	10
		All Kills	1733	74	2	1809
		Vehicle Kills Only	172	14	0	186
Mortars		Sum of Missions	109			109
		Sum of Rounds Fired	2755			2755
		Average of Rounds Fired	***25.28***			***25.28***
		Min of Rounds Fired	15			15
		Max of Rounds Fired	80			80
		All Kills	41			41
		Vehicle Kills Only	0			0

Table A-21: Archive Simulation Summary of Kills and Missions-Rounds Fired.[438]

[438] The term HE is "high explosive", PD is "Point Detonating" fuse, and VT is "Variable Time" fuse. All blank spaces are due either to no rounds being fired in those range bands or the range band exceeds the maximum range of the ordnance indicated.

			Range (Kilometers)			
Platform	**Projectile**	**Category**	**0 - 39**	**40 - 99**	**100 +**	**Total**
CSW	ERM	Sum of Missions	23	51	1	75
	HE PD	Sum of Rounds Fired	34	110	12	156
		Average of Rounds Fired	***1.48***	***2.16***	***12.00***	***2.08***
		Min of Rounds Fired	1	1	12	1
		Max of Rounds Fired	12	12	12	12
		All Kills	3	8	0	11
		Vehicle Kills Only	0	1	0	1
	ERM	Sum of Missions	25	117	30	172
	HE VT	Sum of Rounds Fired	131	1340	473	1944
		Average of Rounds Fired	***5.24***	***11.45***	***15.77***	***11.30***
		Min of Rounds Fired	3	1	5	1
		Max of Rounds Fired	18	24	24	24
		All Kills	27	308	24	359
		Vehicle Kills Only	3	34	3	40
	MK-64	Sum of Missions	17			17
	HE PD	Sum of Rounds Fired	635			635
		Average of Rounds Fired	***37.35***			***37.35***
		Min of Rounds Fired	31			31
		Max of Rounds Fired	40			40
		All Kills	23			23
		Vehicle Kills Only	0			0
	MK-64	Sum of Missions	119			119
	HE VT	Sum of Rounds Fired	4603			4603
		Average of Rounds Fired	***38.68***			***38.68***
		Min of Rounds Fired	5			5
		Max of Rounds Fired	40			40
		All Kills	387			387
		Vehicle Kills Only	21			21
	EX-148	Sum of Missions	16	71		87
	HE VT	Sum of Rounds Fired	116	507		623
		Average of Rounds Fired	***7.25***	***7.14***		***7.16***
		Min of Rounds Fired	2	1		1
		Max of Rounds Fired	24	18		24
		All Kills	11	107		118
		Vehicle Kills Only	2	8		10
	MK-13	Sum of Missions	126			126
	HE VT	Sum of Rounds Fired	654			654
		Average of Rounds Fired	***5.19***			***5.19***
		Min of Rounds Fired	1			1
		Max of Rounds Fired	18			18
		All Kills	115			115
		Vehicle Kills Only	8			8
	MK-13	Sum of Missions	8			8
	SADARM	Sum of Rounds Fired	69			69
		Average of Rounds Fired	***8.63***			***8.63***
		Min of Rounds Fired	1			1
		Max of Rounds Fired	16			16
		All Kills	143			143
		Vehicle Kills Only	55			55

Table A-22: CSW Simulation Total Number of Kills and Missions-Rounds Fired – Part 1.

			Range (Kilometers)			
Platform	**Projectile**	**Category**	**0 - 39**	**40 - 99**	**100 +**	**Total**
CSW	Scramjet HE VT	Sum of Missions	20	48	15	83
		Sum of Rounds Fired	128	421	154	703
		Average of Rounds Fired	***6.40***	***8.77***	***10.27***	***8.47***
		Min of Rounds Fired	2	1	1	1
		Max of Rounds Fired	12	18	22	22
		All Kills	17	96	15	128
		Vehicle Kills Only	1	9	2	12
	Sramjet SADARM	Sum of Missions	17	22	10	49
		Sum of Rounds Fired	251	256	136	643
		Average of Rounds Fired	***14.76***	***11.64***	***13.60***	***13.12***
		Min of Rounds Fired	3	1	8	1
		Max of Rounds Fired	16	16	16	16
		All Kills	314	120	21	455
		Vehicle Kills Only	89	55	10	154
DDG-1000		Sum of Missions	21	275	9	305
		Sum of Rounds Fired	51	1016	35	1102
		Average of Rounds Fired	***2.43***	***3.69***	***3.89***	***3.61***
		Min of Rounds Fired	2	1	2	1
		Max of Rounds Fired	5	5	5	5
		All Kills	35	427	6	468
		Vehicle Kills Only	2	33	2	37
Artillery		Sum of Missions	69			69
		Sum of Rounds Fired	1468			1468
		Average of Rounds Fired	***21.28***			***21.28***
		Min of Rounds Fired	8			8
		Max of Rounds Fired	24			24
		All Kills	273			273
		Vehicle Kills Only	29			29
USMC Expeditionary Fire Support System (EFSS Mortar)		Sum of Missions	84			84
		Sum of Rounds Fired	1373			1373
		Average of Rounds Fired	***16.35***			***16.35***
		Min of Rounds Fired	6			6
		Max of Rounds Fired	30			30
		All Kills	13			13
		Vehicle Kills Only	0			0
Fixed Wing		Sum of Missions	448	27		475
		Sum of Rounds Fired	1729	75		1804
		Average of Rounds Fired	***3.86***	***2.78***		***3.80***
		Min of Rounds Fired	1	1		1
		Max of Rounds Fired	12	6		12
		All Kills	1521	153		1674
		Vehicle Kills Only	172	27		199
Mortars		Sum of Missions	139			139
		Sum of Rounds Fired	2895			2895
		Average of Rounds Fired	***20.83***			***20.83***
		Min of Rounds Fired	15			15
		Max of Rounds Fired	120			120
		All Kills	29			29
		Vehicle Kills Only	0			0

Table A-23: CSW Simulation Total Number of Kills and Missions-Rounds Fired – Part 2.

Target Type	DDG-51	DDG-1000	Aviation	Artillery	EFSS	Mortar	Total
Armor (Tanks)	1	4	34	1	0	0	40
Air Defense Artillery	0	0	7	0	0	0	7
Armored Personnel Carrier	0	1	13	0	0	0	14
Anti-Tank Gun	1	0	3	0	0	0	4
PERSONNEL	132	533	1623	537	23	41	2,889
Multiple Launch Rocket	5	13	29	1	0	0	48
Radar	0	0	0	0	0	0	0
Artillery	5	24	3	4	0	0	36
Mortars	1	1	4	3	0	0	9
Trucks and Vans	1	20	93	46	1	0	161
Grand Total	146	596	1809	592	24	41	3,208

Table A-24: Archive Simulation Kills by Target and Platform Type.

Target Type	CSW	DDG-1000	Aviation	Artillery	EFSS	Mortar	Total
Armor (Tanks)	17	2	53	0	0	0	72
Air Defense Artillery	3	0	13	0	0	0	16
Armored Personnel Carrier	7	1	13	7	0	0	28
Anti-Tank Gun	3	1	3	0	0	0	7
PERSONNEL	1,438	431	1,475	244	13	29	3,630
Multiple Launch Rocket	40	9	17	0	0	0	66
Radar	1	0	0	0	0	0	1
Artillery	86	3	9	0	0	0	98
Mortars	17	0	6	2	0	0	25
Trucks and Vans	127	21	85	20	0	0	253
Grand Total	1,739	468	1,674	273	13	29	4,196

Table A-25: CSW Simulation Kills by Target and Platform Type.

Target Category	Archive	CSW	Change
Air Defense Artillery	303	281	(23)
Armored Personnel Carrier	131	110	(22)
Armor (Tanks)	135	160	25
Artillery	130	180	51
Anti-Tank Gun	34	30	(4)
Mortars	87	89	2
Multiple Launch Rocket System	86	85	(1)
PERSONNEL	7,036	6,696	(340)
Radar	0	1	1
Trucks and Vans	570	522	(48)
Grand Total	8,511	8,153	(358.00)

Table A-26: Difference in Total Kills between Indirect and Direct Fire systems.

The significant difference between the scenarios is the overall increase in Orange Artillery and Tanks killed. While personnel kills went down, the kill increase in tanks and artillery are most significant for the ground force commander.

			Range Bands in Meters			
Platform	**Projectile**	**Category**	**0 - 39**	**40 - 99**	**100 +**	**Total**
DDG-51	ERM HE PD	Total Kills		300.0%		300.0%
		Vehicle Kills		0.0%		0.0%
	ERM HE VT	Total Kills	6.7%	27.1%	4.3%	21.3%
		Vehicle Kills	1.7%	2.2%	1.7%	2.1%
Artillery		Total Kills	42.3%			42.3%
		Vehicle Kills	3.9%			3.9%
USMC Expeditionary Fire Support System		Total Kills	2.5%			2.5%
		Vehicle Kills	0.1%			0.1%
Fixed Wing Aviaton		Total Kills	89.6%	194.7%	50.0%	91.5%
		Vehicle Kills	8.9%	36.8%	0.0%	9.4%
DDG-1000		Total Kills	22.2%	34.8%	4.2%	32.2%
		Vehicle Kills	3.5%	3.6%	0.0%	3.4%
Mortars		Total Kills	1.5%			1.5%
		Vehicle Kills	0.0%			0.0%

Table A-26: Archive Simulation Percent Kills to Rounds by Range.

			Range Bands in Meters			
Platform	**Projectile**	**Category**	**0 - 39**	**40 - 99**	**100 +**	**Total**
CSW	ERM HE PD	Total Kills	8.8%	7.3%	0.0%	7.1%
		Vehicle Kills	0.0%	0.9%	0.0%	0.6%
	ERM HE VT	Total Kills	20.6%	23.0%	5.1%	18.5%
		Vehicle Kills	2.3%	2.5%	0.6%	2.1%
	MK-64 PD	Total Kills	3.6%			3.6%
		Vehicle Kills	0.0%			0.0%
	MK-64VT	Total Kills	8.4%			8.4%
		Vehicle Kills	0.5%			0.5%
	EX-148 HE VT	Total Kills	9.5%	21.1%		18.9%
		Vehicle Kills	1.7%	1.6%		1.6%
	MK-13 HE VT	Total Kills	17.6%			17.6%
		Vehicle Kills	1.2%			1.2%
	MK-13 SADARM	Total Kills	207.2%			207.2%
		Vehicle Kills	79.7%			79.7%
	Scramjet HE VT	Total Kills	13.3%	22.8%	9.7%	18.2%
		Vehicle Kills	0.8%	2.1%	1.3%	1.7%
	Scramjet SADARM	Total Kills	125.1%	46.9%	15.4%	70.8%
		Vehicle Kills	35.5%	21.5%	7.4%	24.0%
Artillery		Total Kills	18.6%			18.6%
		Vehicle Kills	2.0%			2.0%
USMC Expeditionary Fire Support System		Total Kills	0.9%			0.9%
		Vehicle Kills	0.0%			0.0%
Fixed Wing Aviaton		Total Kills	88.0%	204.0%		92.8%
		Vehicle Kills	9.9%	36.0%		11.0%
DDG-1000		Total Kills	68.6%	42.0%	17.1%	42.5%
		Vehicle Kills	3.9%	3.2%	5.7%	3.4%
Mortars		Total Kills	1.0%			1.0%
		Vehicle Kills	0.0%			0.0%

Table A-27: CSW Simulation Percent Kills to Rounds by Range.

Additional hypothetical scenarios: These additional scenarios below provide alternative views to the employment of a CSW in the future. These scenarios were developed with input from many different officers from across the services. Final decision and presentation, errors and omissions are the study author's alone.

> **Situation:** Fall 2015 off Korea. Relations worsen after North Korea conducted a series of special operations raids into South Korea. North Korean forces are massing between Wonsan and Singosan, preparing for an attack south towards Kumhwa, Pyonggang, and Chorwon. A Joint Task Force is assembled and comprised of the 4th Brigade, 25th Infantry Division (Airborne) an augmented Marine Expeditionary Brigade (MEB), one Carrier Strike Group (CSG) and one Expeditionary Strike Group (ESG) with a Capital Surface Warship (CSW). The Sea Base is established 150 miles off the North Korean coast. A second CSG is located in the Yellow Sea. The remaining CSG's are conducting operations off Taiwan, the mid east and Africa. On D-1, North Korean Special Forces strike simultaneously on both coasts, and the massed forces begin moving at 2100 hours.
>
> **Execution:** The U.S. and South Korean National Command Authorities notify forces to execute operations. The airborne brigade conducts a drop at D Day, 0400 on the road near Changdo-ri. Strikes from Tomahawk missiles, naval air and Air Force assets begin air superiority and interdiction strikes at D-1, 2100 hours. North Korean forces use their anti-air systems skillfully and a few coalition aircraft and Tomahawk missiles are shot down. Some close air support missions are disrupted and engagement rules are adjusted, reducing close air support effectiveness until air superiority is firmly re-established two days later. At D Day 0300 hours Special Forces teams sends a fire mission against hardened anti-air systems and artillery near the drop zones. The JFT quickly de-conflicts coordinated airspace. The CSW's Naval Fire Control System (NFCS) receives the mission and destroys the surface to air missile targets with long range projectiles at ranges of exceeding 300 miles from the ships. The airborne drop is unopposed by anti-air assets as a result of this successful gun-strike. The deep penetrating scramjet projectiles destroy all hard surface to air and surface to surface targets before they have a chance to fire on coalition forces. During MEB landing operations at Kosong, AEGIS radars detect enemy artillery fire from previously undisclosed artillery positions. The target location data is transmitted to the CWS's NFCS and these targets are destroyed within five minutes by "brilliant munitions" equipped 600 pound 280mm sabot projectiles fired from 25 miles off shore. Naval aviation destroys additional mobile forces moving to attack the landing force. These actions enable the landing force to seize its objective and halt the North Korean offensive. Negotiations for conflict termination begin within 24 hours.

> **Situation:** Summer 2014 at the Strait of Hormuz. Coalition naval forces are operating in the Persian Gulf conducting freedom of the sea operations. While coalition forces are decisively engaged in simultaneous operations off Korea, Taiwan and the Lebanon, the Iranians close off the Strait of Hormuz with coalition naval forces now bottled up inside the gulf. One CSG, and one ESG

with a CSW are operating in the Indian Ocean. All other significant naval forces are otherwise committed.

Execution: Two days after the Iranians announce closure of the straits, the Coalition Force commander deploys the ESG to force the straights in consonance with coalition and CSG air power. As the ESG with additional coalition warships approaches the straits, the CSW conducts gunnery practice as a show of force. Iranian forces pull back from Jask, Kangan and Kuhestak. As the ESG enters the straights, a pair of gunboats tries to strike the group, and are promptly sunk by U.S. destroyers. Simultaneously a missile battery at Qeshm fires several sunburn and C802 missiles, and within five minutes, thirty 900 pound sabot projectiles destroy the batteries. One coalition destroyer is hit and sinks; the CSW is struck and sustains superstructure damage that is later repaired at Bahrain. Within the hour, major caliber gun, Tomahawk and naval air strikes on Qushm, Bandar-e Abbas and other targets within the Horozgan area inflict significant damage to Iranian defenses. Iranian preparations to use nuclear weapons are countered by diplomatic assurances that U.S. will execute full nuclear response coupled with Tomahawk and hard target penetrating gun strikes against key Iranian infrastructure. Within 24 hours, Iran announces it has opened the straits to coalition naval forces.

Situation: 2014 somewhere off the African Coast. A major non-combatant evacuation operation is underway supported by an ESG with a MEB. During the evacuation, two Al Qaeda camps are discovered 300 miles inland by Special Operations Forces (SOF). These are time sensitive targets and must be struck within 15 minutes. Significant man portable anti-aircraft weapons are present.

Execution: The ESG flagship, a CSW, receives the fire mission and with no airspace to deconflict, answers the SOF call for fire with 10 precision guided 400 pound scramjet projectiles, reducing the main camp to rubble in less than two minutes of shooting. Within five minutes of opening fire, both camps are destroyed and once on the objective, the SOF determine all critical leadership targets were killed, two in deeply buried caves 35 feet underground.

Situation: Summer 2030 off Taiwan. Eight CVN's are supporting coalition forces engaged in operations in Korea and the Middle East. Chinese forces begin massing Shantou, Xiamen and Fuzhou in apparent preparations for an attack on Taiwan. Within 24 hours, the last two available Carrier Strike Groups (CSG) and one Expeditionary Strike Group (ESG) with two new CSW's with major caliber electro-magnetic rail guns are deployed with a MEB as a show of force against the Chinese. The Sea Base is 150 miles off Taiwan ready to react to any Chinese action.

Execution: At D+4, two coalition battle groups with two CSW's, a CVN, fifteen coalition AEGIS warships and five attack submarines move into position as a show of force against the Chinese. Twelve Chinese destroyers attack the task force with Sunburn missiles, and are promptly sunk by Harpoon missiles, naval aviation, submarines and major caliber gunfire. Of the 15 enemy missiles fired, one missile succeeds in striking the heavily armored CSW, resulting in slight damage to the superstructure and destruction of one of two main battery fire control stations. A coalition DDG is struck and subsequently sinks. Simultaneously, hundreds of Chinese aircraft rise to attack the naval forces and are engaged at long range by naval AEGIS system launched Standard Missiles and coalition aircraft. Due to expected air threat, only SSGN's have

significant Tomahawk capability. Surface ships primarily carry standard missiles. Shortly after this engagement, the force detects artillery and missile firings from the vicinity of Changle against Matsu Tao (Taiwan sovereignty) and the mainland of Taiwan. Within one minute both CSW's opens fire with precision guided 2,200 pound 16-inch electro-magnetic shells. Fifteen minutes and 150 projectiles later, the concrete reinforced artillery and missile sites are destroyed. CSW's then begin destructive fire on Chinese airfields from ranges of 250-600 miles using long range electro-magnetic shells. Creating craters over 45 feet in diameter, the airfields are reduced to uselessness. Within 24 hours after this gun-strike, the Chinese begin pulling forces away from the coast and initiate talks with the United States. The entire action from start to finish takes approximately six hours

Appendix G:
Additional Information related to Battleships

This appendix provides additional information on *Iowa* class ships as they relate to the NSFS and capital surface warship roles and missions.

Reasoning behind returning battleships to the fleet in the 1980s: Mr. Charles E. Myers was instrumental in the reactivation of the battleships in the late 1970s. Mr. Myers recounts his considerations and the path, which led to reactivation of the *Iowa* Class Battleships. This began with his concerns and responsibilities for DoD Research and Development of Tactical Aircraft and Weapons as the Director for Air Warfare in OSD, circa 1973-78.[439]

> In addition to concerns regarding preparations for a major conflict and the mounting cost of tactical fighter and attack aircraft in the "Post Vietnam" constrained budget environment, there was evidence of significant improvement in enemy air defense technology, which for many, projected an environment so hostile to TACAIR as to severely reduce its application to situations only where "there is no other way". At the same time, pondering the future interests of the U.S. on the global stage, I embraced the view that "the valuable hard assets, real estate, art, fiscal resources, ports/transportation/access routes and population centers of the world which may be really worth going to war over, lie primarily within 25 miles of the sea/sand interface: “within the littorals".
>
> Relating these thoughts to the recent war in SEA, I and my staff performed a survey of the targets in North Vietnam which our war planners had selected and concentrated on for the past five years; it was noted that over 80% of them lay within the 25 mile band of the coast, including the Than Wai Bridge where we had suffered the loss of over 65 airplanes.
>
> From my experience as both an Air Force and Navy fighter/attack pilot during WWII and the Korean War, I recalled the extensive effort to interdict the route structure in the coastal regions, remembering that the Navy's contribution to the effort had included day, night and all weather bombardment from ships, especially the Salem Class Cruisers and the Battleships.
>
> Further, I remembered the "highpoint" of Navy surface to surface fires which permitted the graceful withdrawal under pressure of our ground forces from Hungnam behind a "controlled retracting shield of steel rain". Noting that the capability to create such fire support had been erased by choice (imagine substituting TACAIR), I began conversing and writing about the need for a futuristic dedicated fire support ship and proposing that the *Iowa* Class Battleships be returned to the fleet to fill the gap until equivalent fires capability with their survivability could be demonstrated with a futuristic Navy ship. In

[439] Interview, Mr. Charles E. Myers, 5 March 2007.

> my discussions and writings, myself and an expanding supporting cast of Naval Aviators (to eventually include Admiral/Senator Jeramia Denton, war prisoner who had been shot down while attacking the Than Wai [Tanh Hoa] Bridge) exposed the limitations of TACAIR for the task of all weather strike, interdiction and direct fire support for infantry engaged in future Littoral Warfare.
>
> Our thesis was simply that for each target set, there is an "optimum" or most cost effective means; TACAIR is not always the best or most efficient choice. Also, we emphasized a "Washington" concern which we referred to as the "Gary Powers" syndrome: the political impact of having our surviving pilots captured by the enemy. During global Military Political Gymnastics (a favorite National Pastime), captured pilots become very useful in the hands of the enemy; ergo, we cannot afford to be casual about the application of manned aircraft.
>
> In the end (80-81), the nucleus of aviators, with the all important assistance from the Commandant of the Marine Corps, General Bob Barrow and active support on Capital Hill from the new Secretary of the Navy, John Lehman and CNO Hayward (both from the aviation community) prevailed in reactivation. But, in the end, we failed regarding the quest for Navy development of a suitable Capital Ship to fill the WARTIME surface to surface fire support gap which has become ever more critical as air defense technology advances and becomes available throughout the world.[440]

The last sentence is most significant for the shortfall that Mr. Myers speaks, the failure to field a capital ship, is the central to this study.

Related to Mr. Myers experiences are those of Admiral Harry Train who also expended considerable effort to return the Iowa class ships to the fleet. His experiences relate as follows:

> From August 1978 to October 1982, as the Commander In Chief of the Atlantic Fleet and Commander-in-Chief of U.S. Atlantic Command, I was responsible for force levels within the Atlantic Command, execution of the war plans for the conduct of the Battle of the Atlantic and deterrent measures required to prevent such a war. One of these deterrent measures was peacetime presence of Capitol Warships.
>
> The Presidential mandate in the late 1970's to create and sustain dominant maritime presence in the Indian Ocean greatly increased the demand on the aircraft carrier force. The directive required two carrier battle groups and reduced carrier presence in the Pacific and elsewhere. It became apparent in areas where naval presence as practiced by a carrier battle group could have a similar level of presence using a battleship as lead instead of a carrier. Such presence could not be effectively achieved by deployment of small cruisers leading surface action groups. This holds true in today's strategic and operational environment.
>
> When deprived the use of aircraft carriers, the battleships are a credible substitute. On this line of thinking, I made my pitch to the House Armed Services Committee (HASC).

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[440] Ibid.

> They came down to Norfolk in the early 1980's and over the course of two days of hearings they were persuaded that my concept was valid. In the course of approving the concept, they specifically expressed concern over the possibility of these ships become flag officer toys. I assured them that would not be the case. The most important point was that I brought the Iowa class ships back active in the fleet.[441]

Admiral Train brings into sharp focus the capabilities that lead him to advocate for Iowa class reactivation in the early 1980s. Of greater significance is his assertion that capital surface warships provide capabilities that are unmet today.

Issues related to reactivation and operational reliability: In 1987, Arthur Romano documented the reactivation of the ship's 16-inch gun turrets. At that time he was the Director of Gun Division Naval Sea Systems Command. He states the following;

> Reactivation of the 16-inch turrets was accomplished with few major problems because of the care with which they were preserved when deactivated. The reactivation effort basically involved cleaning, reassembling, adjusting, arid testing each component of the turret individually until all components were operating and then testing the entire gun as a unit…reactivation was accomplished with no major problems or controversy…the biggest effort required to reactivate the turrets have been the cleaning of the preservative from the inside of the hydraulic systems…the equipment had not rusted or deteriorated since deactivation. Generally a systematic cleaning, reassembling, adjustment and testing was all that was needed to reactivate the turrets.[442]

The paper outlined a few technical issues, such as erratic oscillation problems with the elevating power drives on two of USS *Iowa's* guns. These problems existed when the ship was decommissioned and were not fixed. After extensive work and reverse engineering, they were ultimately solved during the ship's reactivation in 1984.[443]

In consideration of possible future reactivation issues, it should be noted that during the 1980s reactivation, only one item throughout the entire 16-inch gun turret system was found not to operate within specifications – an air pressure reduction valve for each 16-inch breach mechanism. A current production commercial off-the-shelf

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441 Admiral Train Interview.
442 Romano, 1, 2, 25.
443 Ibid., 9-12.

valve was found to be a direct replacement and commercial repair kits were available to repair the valves in the future.[444]

Potential overpressure damage to modern equipment from the firing of the 16-inch guns was successfully addressed through a combination of restricted firing arcs, repositioning of modern equipment, and altering the firing sequence of the guns.[445]

Twenty-six spare 16-inch gun barrels exist for the battleships.[446] However, there are issues related to the existing gun barrel life, especially as it relates to high-pressure munitions.[447] Options exist to construct new barrels that will be much stronger, last longer and be lighter in weight.[448] Initiating design and construction of additional replacement barrels would both improve the existing stock of 16-inch gun barrels as well as provide the required development of newer and better guns for future mounts and systems.

The following statement was the position of the Director, Gun Division, Naval Sea Systems Command in the 1980s.

> By reactivating the 16-inch turrets the Navy has obtained a highly capable weapon system, which can engage a wide range of surface targets in all weather conditions for a long period of time better than any other system the Navy has in the Fleet. Even in peacetime the 16-inch turrets on the battleships provide an impressive naval presence.[449]

A more significant discussion is one related to reliability of the ship systems. While they are old, they have strong record of technical reliability. The GAO stated in

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444 Ibid., 13.
445 Ibid., 15.
446 *Navy is Complying with Battleship Readiness Requirement*s, 6.
447 Romano, 16-23.
448 Ibid., 23. The document further states "Because of the superior steels now available and the increased capabilities of the forging industry, a much simpler 16-inch gun barrel design is now possible. The new 16-inch gun barrel would be made from a one piece forging of high strength steel in accordance with MIL-S-46119 with an elastic limit of 160,000 pounds per square inch (psi) to 180,000 psi used in all gun barrels currently being manufactured. The mono-block 16-inch gun barrel would have an adapter for interface with the existing recoil system, slide assembly and yoke assembly, and to assure proper operation of the turret elevation drive systems. As an alternative to an all new gun barrel, some additional strength arid wear life can be gained by relining existing worn. 16-inch gun barrels with liners made from MIL-S-46119 steel."
449 Ibid., 25.

1991 "…between 1984 and 1989 the battleships operated without any failures that had a major impact on or precluded the ships from performing a primary mission for a substantially greater percentage of time than did surface combatants as a whole. The battleships had the better record in this regard for 19 of the 24 quarters in this period."[450] This level of readiness should be capable of replication today assuming the Navy placed these ships into storage with the same level of care as they did in the 1950s and 60s. In fact, it appears the concerns regarding the replacement of parts designed in the 1930's and 1940's were less problematic than originally feared.[451]

Survivability: One critical aspect of these ships is their hardness. In addition to the material discussed in Chapter 5, there are two specific instances when modern U.S. battleship physical strength was tested. The first was the torpedoing of the USS *North Carolina* in 15 September 1942. The ship was struck by one Japanese torpedo directly abeam and twenty feet below the water line of the number one turret, opening a hole thirty-two feet long and eighteen feet high.[452] The torpedo had an 891-pound warhead.[453] The ship righted its list in less than six minutes, increased speed from nineteen to twenty-five knots, maneuvered radically, and stayed at battle stations for the rest of the day.[454] The shock effect was not serious with damage to piping *remarkably small*, and no flexural vibration.[455] The conclusion of the official report stated: "The damage was sustained by *North Carolina* without marked reduction of her fighting ability and was ably handled by the ship."[456]

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[450] Government Accountability Office. *Issues Related to Navy Battleships (GAO-06-279R)* (Washington, DC: GPO, 13 December 2005), 24-25.
[451] Muir, *The Iowa Class Battleships*, 123-124.
[452] Riley, 221.
[453] See http://www.battleshipnc.com/history/bb55/wwii/battles/longlance.htm, accessed 1 April 2007.
[454] Ibid., 220-221.
[455] Ibid. 228.
[456] Ibid.

On the night of 15-15 November 1942 the USS *South Dakota* engaged in combat against one Japanese battleship, two heavy and one light cruisers and nine destroyers. During this action the USS *Washington* sunk the Japanese battleship *Kirishima*. One 5-inch, six 6-inch, eighteen 8-inch and one 14-inch projectile struck the USS South Dakota.[457] The ship, while suffering damage to radar and communications equipment, was not impaired physically.[458] The hits the ship sustained reinforced the retention of heavy armor and a heavily armored conning tower that if absent would have resulted in destruction of her conn and command and control.[459] However, the loss of radar antennas did severely reduce her ability to fight at night.[460] This level of protection has utility today and with modern systems would be even more robust. The significance of the hardness of these ships should not be lost on U.S. leadership today. Modern warships are relatively soft compared to a ship of the *Iowa* class and generally do not sustain damage and continue operations.[461] Admiral Train provides additional views on the value of the *Iowa* class ships:

> The battleships were built to survive and project force. They can withstand impact of 2,000 pound projectiles and bombs flying through the air at speeds greater than three times the speed of sound. They can withstand other forms of kinetic weapons that no other ship in the Navy can withstand. They are large, highly visible and capable of dominating the sea. They are easily adaptable to support new Surface-to-Air and Surface-to-Surface Missiles, such as installing the vertical launch system, greatly improve upon existing capabilities. Future missile capabilities other than VLS should be evaluated for inclusion in modernization options. These ships are indeed a very credible presence where they do not have to confront an air threat (unsupported) similar to that encountered off the Kola Peninsula (Murmansk), the home of the Soviet land based air threat.[462]

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[457] Ibid., 230-234.
[458] Ibid., 234.
[459] Ibid., 232.
[460] Ibid.
[461] Details of damage to USS Princeton, see http://navysite.de/cg/cg59.html accessed 24 October 2006. For a overview of combat damage to various warships see http://www.dtic.mil/ndia/2001ewc/marsh.pdf accessed on 1 April 2007. An overview of damage to the USS Cole is available see http://www.jinsa.org/articles/articles.html/function/view/categoryid/164/documentid/1047/history/3,2360,656,164,1047 accessed on 1 April 2007.
[462] Admiral Train Interview.

Issues with employment in the 1980's: Former Secretary of the Navy John Lehman took significant issue with the employment of the USS *New Jersey* off Lebanon. On 29 September 1982 the first Marines landed in Beirut, beginning a presence mission in Beirut, which was ill defined.[463] On 18 April 1983, a suicide bomber in a pickup truck destroyed the U.S. Embassy in Beirut.[464] To the lack of U.S. response Lehman wrote:

> If we were to maintain a serious role, then we had to retaliate against those who did it. We did not. We shrank from it …until finally the bureaucracy pushed and squeezed it down the "memory hole." Down with it went Ronald Reagan's and America's credibility in the Middle East…. The marines would be put in the line of fire between emboldened radical factions who had lost any fear of retaliation from the United States. The environment around the airport deteriorated steadily after the embassy bombing. During the summer, artillery and small arms fire started falling on the compound.[465]

As the Marines in Beirut began taking fire from Syrian and other forces, Lehman and the Navy chain of command decided to deploy the USS *New Jersey* to provide supporting fires. This idea immediately ran into roadblocks from European Command, which strongly opposed the ship's presence. Lehman stated:

> With regard to sending the *New Jersey*, the opposition was particularly exasperating. Neither Jim Watkins nor I were ever given a military explanation for the opposition to sending the *New Jersey*, which stemmed from the European Command. We simply could not credit the rumors that SACEUR's dislike of the maritime strategy and antagonism to the battleship program weighed more heavily than the security of the marines. Yet by early September Watkin's and my recommendation had simply been dismissed out of hand, without even a chance to discuss the merits.[466]

Ultimately, President Reagan ordered the USS *New Jersey* deployed to Lebanon, arriving on 24 September 1983.[467] On 23 October, a suicide bomber destroyed the Marine Barracks.[468] President Reagan desired retaliation, but General Vessey (Chairman, Joint Chiefs of Staff) opposed a strike.[469] Ultimately, an air strike was chosen, instead of a naval bombardment with Syrian fire against our reconnaissance aircraft on 3 December

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463 Lehman, 304-305.
464 Ibid., 305
465 Ibid., 306.
466 Ibid., 310. SACEUR is the Supreme Allied Commander, Europe.
467 Ibid., 310.
468 Ibid., 312.
469 Ibid., 319-320.

being the actual trigger to launch the strike.[470] General Vessey and Paul Thayer (Deputy Secretary of Defense) stated the USS *New Jersey* could not reach the targets and lacked the accuracy, which Lehman stated was false as the 16-inch guns could reach all proposed targets.[471] Lehman further described the targets and situation as follows:

> Prior to December 3 the European Command had rejected the Baalbek target package prepared by Lyons (not invented here) and, exactly as in Vietnam, prepared instead a lot of valueless target packages composed of scattered suspected antiaircraft sites for potential retaliation, if ordered... four sets of targets. Three of them were Syrian artillery and antiaircraft positions, and one of them was a radar site...The radar site could easily have been handled by the *New Jersey*'s guns, but the other target sets were small antiaircraft gun emplacements and possible missile emplacements whose precise coordinates were not finally known. Many of them were on the eastward-facing slopes of the hills, which would have meant that the sixteen-inch guns would have had to use area saturation rather than precise targeting. Because the targets were so inconsequential and small, they could not be engaged by precision radar- or laser-guided munitions but would require visual identification by the aviators.[472]

The confusing and ill-timed air strike that followed on 4 December 1983 resulted in two U.S. aircraft shot down attacking targets better left to guns.[473] On 14 December 1983, the USS *New Jersey*, in her first firing mission, fired 11 rounds and destroyed six anti-aircraft sites, however, a reconnaissance flight to fully assess the damage was denied by European Command in Stuttgart.[474] Finally, on 8 February 1984, after the Marines were ordered to withdrawal, the USS *New Jersey* fired her most significant mission as related by Lehman below:

> Syrian artillery batteries began firing into the Christian-held areas of West Beirut, creating serious civilian casualties. They fired more than 5,000 rounds before the decision was made to answer the fire by responding with the *New Jersey's* sixteen-inch guns. The army provided the *New Jersey* with grid coordinates based on their R-TAB radar, which tracked the shells and calculated the position of the firing guns. The *New Jersey* fired 270 rounds and totally silenced all Syrian batteries. In subsequent weeks it was confirmed that eight Syrian batteries disappeared completely from their orders of battle, having been totally destroyed. Admiral Tuttle requested a TARPS mission to get detailed battle damage. For reasons never explained, EUCOM headquarters suspended all TARPS (reconnaissance) missions for two weeks. Thus the only confirmation of the effectiveness

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470 Ibid., 320.
471 Ibid., 320-21.
472 Ibid., 321.
473 Ibid., 323-326.
474 Ibid., 327.

> of the *New Jersey's* guns came from a CBS News interview of a Syrian spokesman who said that the *New Jersey* had killed only innocent civilians and goats. Meanwhile, back in Washington, it was like pulling teeth to try to find out how the decision had been made to reject Lyon's Baalbek target in favor of EUCOM's useless targets and then compounding the mistake by using A-6s instead of the *New Jersey* in the first place.[475]

Lehman's ultimate aggravation was at the Navy's failure to push the use of the USS *New Jersey* and the antiquated manner in which the air strike was conducted. Failure to use the ship in place of the air strike cost the U.S. Navy two aircraft lost, one prisoner and one dead pilot, and failed to silence the Syrian Artillery. After the USS *New Jersey* conducted her gun strike, all Syrian batteries were silenced. Lehman felt that left to their own devices, the Navy never would have used the USS *New Jersey* and instead would have just used more aircraft and bombs and put more fliers at risk.[476] The most apparent lesson is that if the military does not want to use a weapons system that clearly is the most appropriate, there must be a powerful sponsor of that system to ensure it is used. Further, if the system is not inculcated into the service culture, and the sponsor departs, the likelihood the system will be used diminishes greatly.

Utilization issues: The issue of utilization is a potential stumbling block for future CSW employment. This point is illustrated by an assessment of major incidents in the 1980s where battleships could have substituted for aircraft carriers.

Major Incidents where Carrier battle groups were used	Could a Battleship battle group substitute?
Mayaguez Retaliation (1975)	Yes
Lebanon evacuation (1976)	Yes
Iranian hostage rescue (1980)	No
FON Operations, Libya (1981, 1986)	Mostly
Bekaa Valley (1983)	Yes
Grenada (1983)	Partly
Terrorist air interception (1985)	No
Libya bombing (1986)	Mostly (7 of 9 targets)
Persian Gulf FON operations (1987-1989)	Mostly

Table A-27: Mission Substitution Analysis.[477]

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475 Ibid., 327.
476 Ibid., 330-331.
477 Cancian, 11.

Combining the information in Table A-27 with the previous material from Secretary Lehman indicates a failure to appropriately use these platforms. A further view to use of the major caliber guns of a battleship in the Libyan strike of 1986 states:

> The Air Force bombing of Libya…had little military, as opposed to political, result. In the strike on Ghadaffi's HQ very few aircraft scored hits. [478]

The unwillingness of the Navy to employ the platform, and strategies to mitigate that problem, are a serious consideration in any proposal to reactivate battleships and/or to construct the future CSW.

Battleship Performance in Desert Storm – the destructive power of major caliber guns: In addition to the material covered in Chapter 1, a narrative from a ground force officer (customer) is worth noting. Lieutenant Colonel (retired) Dan Dall, an officer assigned to the CENTCOM J-2, was at the Eastern Coalition command post outside Kahfji. He was witness to the bombardment of Iraqi artillery positions by the USS *Wisconsin* the evening before the ground assault and participated in the assault on the following day. On 20 April 1995 he wrote to the former Captain of the USS *Wisconsin*, then Rear Admiral David Bill, to share his appreciation for the work of the ship. Portions of his letter follow:

> At midnight, the building shook…I heard for the first time the whooshing sound those huge rounds made as the traveled through the air on their way over our positions. With each successive round, the building seemed to sway and shake a little more than the time before. I was impressed, until I saw the flash of impact from the first round, then my reaction turned to awe. The fire lit up the desert sky like concentrated lightening bolts hitting the earth. The explosion, although somewhat dampened because of the distance factor, made me extremely glad I wasn't too much farther north than we were.
>
> Your prep seemed to last for hours and all I could think of was what it must be like on the long end of those guns. I honestly remember asking myself, "Are they hitting anything or are they just making big holes in the sand?" At 0400 our own artillery began their prep…155s compared to what we had just experienced seemed paltry but it was ours!
>
> At 0600, through a light mist, the time for idle worry was over. We crossed the breech area and took our chances against those positions and whatever they had stored in them.

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[478] Ibid., 10.

> Cautious at first, maybe apprehensive being a better word, we soon encountered our first Iraqis. They fired a few shots to maintain their manhood but quickly threw out their weapons and put up their hands. They were in pitiful shape. Within a very short time we had taken almost 500 prisoners. At about 0900 we encountered the first of many of those artillery positions. My awe was now turning to elation! The devastation was complete. Pieces and parts of metal were strewn all over the desert floor. The positions they had dug for their artillery had become craters, the earth had taken a severe pounding and they got in the way. Having been around 155s all my life, I knew they did not do this. I also knew the B-52's that had been flying over our sector had been targeting deeper areas…this had to be the work of the *Wisconsin*, a conclusion that I was later told had been confirmed.
>
> Your work was superb, your accuracy deadly and your effectiveness complete. You had made the job of these old grunts much easier. NOT ONE ROUND was fired against us from those positions. Their bunkers had collapsed in on themselves and their capability to resist was totally negated.[479]

The level of destruction illustrated in the letter indicates the capabilities of major caliber guns against dug in troops and artillery.

Concerns related to battleship decommissioning: Since the decommissioning of the last battleships in 1992, Naval Surface Fire Support capabilities have been cited as inadequate by multiple sources.[480] Congress initiated actions to improve the naval fire support capability, beginning by directing the Navy to craft a Naval Fire Support development program in 1993.[481] Two years after that Congressional directive to form the NFS development program, the U.S. Navy struck all four *Iowa* class battleships from the Naval Vessel Register (NVR).[482]

The Fiscal Year 1996 National Defense Authorization Act directed the Navy to restore two of battleships to the Naval Vessel Register and maintain their

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[479] Interview, LTC (ret) Dan Dall, 8 March 2007.

[480] Global Security.Org., "Five Inch Ammunition." Last updated 1 March 2006, accessed on 1 November 2006 at http://www.globalsecurity.org/military/systems/munitions/5in.htm; James W Hammond III. "NSFS Shortfalls." *Marine Corps Gazette*; March 2006; pg. 31; Sandra I. Irwin, "Marines Clamor for Long-Range Artillery at Sea." *National Defense*, January 2002; Stephen H Keller, "Naval surface fire support: On target." *Sea Power*; September 2001; pg. 41; Patricia Kime. "LRLAP Will Boost Fire-Support Range." *Sea Power*; July 2004; pg. 23; Jason Sherman, "Keeping up with Jones." *Armed Forces Journal International*, June 2000, 14. All of these articles have statements either acknowledging there has been a shortfall since the decommissioning of the Navy's last battleships or that some quarters desire their return to overcome the shortfall in fire support. The interview with General Jones identifies the naval fire support gap as a major concern.

[481] CNA, *NSFS COEA*, Cover Letter.

[482] *Navy is Complying with Battleship Readiness Requirement*s, 4.

infrastructure.[483] The Navy complied with this statute two years later in 1998.[484] The author of this study has not located a citation to justify the two years of non-compliance. This statute required the Secretary of the Navy to certify in writing to the Congress that a replacement system that matched or exceeded the capabilities of the *Iowa* class battleships was fielded and operational in the fleet prior to striking the last two ships.[485]

In 1999, the GAO reported to Congress that the Navy was complying with battleship readiness requirements. No systemic shortfalls or issues of non-compliance were noted in the report.

Navy asserts battleships do not meet Joint Fire Support requirements: In 2005 the Government Accountability Office outlined DoD's and the Navy's many reasons why it desired to strike the ships. The Navy cited Joint Fires capabilities such as air, Army and Marine Corps artillery/mortars, the Extended Range Munition for the DDG-51 class ships and the Long Range Land Attack Projectile (LRLAP) for the DDG-1000 ships as mitigating known gaps in Naval Surface Fire Support.[486] While these guns bring new and useful capabilities to the fleet, they are not as lethal as 16-inch or other major caliber guns in general. The Navy made several questionable assertions to the GAO regarding battleships and their guns. The first is the inaccuracy of the 16-inch rifles.[487] The figures cited were significantly larger than documented performance.[488]

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[483] "Battleships Bow Out," *Jane's Navy International*, 100, no. 2, 1 March 1995; Roman Schweizer, "After Two-Year Delay, Navy Complying With Battleship Preservation Law", *Inside the Navy*, 19 April 1999.

[484] *Navy is Complying with Battleship Readiness Requirement*s, 4.

[485] "Senate Heeds Mahan, Instructs Navy To Bring Back Two Battleships," *Inside the Navy*, 24 July 1995.

[486] Government Accountability Office. *Issues Related to Navy Battleships (GAO-06-279R)* (Washington, DC: GPO, 13 December 2005), 4-5, 9. Joint Fires are fully identified as tactical aviation, Surface-to-surface rocket systems (HIMARS, MLRS, ATACMS, Tactical Tomahawks), Army and Marine Corps artillery (105mm and 155mm howitzers). During a forced entry over the shore or during a deep over the horizon insertion inland, the ground force will lack its organic fire support systems.

[487] Ibid, 12. 16-inch rifles were cited as having range errors up to 900 meters and deflection errors up to 400 meters.

[488] U.S. Department of the Army and the Navy, *Joint Munitions Effectiveness Manuals: FM 101-61-5-2 / OP 4388 / FMF 4-71-01B* (Washington, DC: GPO, Revision 2, 1 November 1990), A94, A97. This

Chapter 5 outlined how accuracy can be improved through new precision guidance capabilities that can be applied to 16-inch projectiles. These capabilities do not appear to have been considered. Key to accuracy, besides precision guidance, is ensuring the propellant performs well and has very low round to round muzzle velocity variation. See Appendix I for additional discussion of this issue. Another assertion was replacement of the existing steam fired boilers and engines with gas turbines.[489] The high readiness ratings of battleships cited by the GAO in 1991 calls the need for this radical modernization into question.[490] There are parts that do require replacement due to conversion to diesel fuel in the 1980's, but these do not require replacement of the entire propulsion system.[491] The Navy also asserted that 16-inch guns as apparently evaluated in the Initial Capabilities Document (ICD) could not meet volume fires requirements.[492] The author of this study found no evidence of analysis pertaining to 16-inch guns within the ICD documentation. The Navy outlined additional battleship shortfalls as follows:[493]

1) Modernized battleships will not significantly reduce joint fires risks or meet long term joint fires capabilities requirements.

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document shows far better performance of the 16-inch rifles than the Navy provided to GAO. U.S. War Department, *FT 16-1-E, Firing Table for Gun, 16-inch, Mk.II (Navy) firing Projectile, A.P., 2,240 pound, Mk. XI* (Washington, DC: GPO, 1942), 95. At maximum range of 41,200 yards, the firing table accuracy was up to 160 yards in range and 18 yards in deflection – a huge difference from the Navy citation on page 12 of the 2005 GAO report.

[489] Government Accountability Office, *Issues Related to Navy Battleships (GAO-06-279R)* (Washington, DC: GPO, 13 December 2005), 16.

[490] Government Accountability Office, *BATTLESHIPS: Issues Arising from the Explosion Aboard the U.S.S. Iowa*. (Washington, DC: GPO, 29 January 1991), 25. "…between 1984 and 1989 the battleships operated without any failures that had a major impact on or precluded the ships from performing a primary mission for a substantially greater percentage of time than did surface combatants as a whole. The battleships had the better record in this regard for 19 of the 24 quarters in this period." It is unlikely the propulsion system has degraded significantly during the 16 years since the battleships were placed in storage if they were maintained as the Navy reported in 1999.

[491] Interview, van der Schroeff, 27 September 2006. During this interview he stated the fuel pipes within the ship were rusting due to the change in fuels. The old Navy Black bunker fuel was a viscous, lubricating and corrosion inhibiting type of fuel. Diesel fuel is not nearly as corrosion inhibiting and has a noticeable level of water. This caused the pipes to rust and create what the USS *Wisconsin's* Engineering Chief told Captain van der Schroeff was a "fuel-water sprinkler system". This requires replacement of a significant amount of fuel pipes within the ship.

[492] Government Accountability Office. *Issues Related to Navy Battleships (GAO-06-279R)* (Washington, DC: GPO, 13 December 2005), 13.

[493] Ibid., 4-5.

2) Battleships are too expensive to operate.[494]
3) Battleships are too manpower intensive (1,500 personnel required).[495]
4) DDG-1000 with LRLAP and DDG-51 with ERM and other Joint Fires fill the majority of the identified capabilities gaps.

Given the initial results of the FireSim XXI analysis, the first bullet appears questionable at best. The performance of the CSW, in essence a modernized battleship, calls bullet number four into question as well. As a point of fact, based on the FireSim XXI simulation, the CSW is far more lethal than either DDG-51 with ERM or DDG-1000. DoD stated that while 16-inch precision-guided munitions could be developed, those munitions would not be available until after the DDG-1000's Advanced Gun System was deployed.[496] This is not congruent with already tested long-range 16-inch projectiles and the success of the Army's EXCALIBUR and Precision Guidance Package technologies as outlined in Chapter 5. The cost and manpower arguments, when placed into context of the rest of the fleet's fires capabilities, beginning with the operating costs of aircraft carriers with air wings, appear specious. The FireSim XXI simulation indicated that eighty sorties that included one B-52 were roughly equivalent to two CSW's for kills. This calls cost and crew complaints into question without additional explanation. Admiral Train provides another way to view the Navy's assertions to the GAO:

> The argument that Iowa class ships are too old technologically and vastly different from the current fleet is specious and does not alight with similar approaches such as SLEP for aircraft carriers and service longevity of the B-52.[497]

In 2005, Congress repealed previous statute to allow the Navy to strike the last two battleships from the Naval Vessel Register.[498] This is in keeping with what the Government Accountability Office reported in 1999:

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494 Ibid., 5.
495 Ibid., 6.
496 Ibid., 14.
497 Interview, Admiral Harry Train, 2 May 2007.
498 U.S. Congress, *National Defense Authorization Act for Fiscal Year 2006*, 109th Congress, 1st sess., H.R. 1815, GPO. 2005, 288.

> Navy officials state that they plan to remove the battleships from the NVR as soon as they can certify that the performance of the gun, projectiles, and missiles being developed equals or exceeds that of the battleships."[499]

However, the author of this study has been unable to obtain documentation of Navy compliance with the 1996 National Defense Authorization Act provision requiring the Secretary of the Navy certify that a replacement capability was active in the fleet. The law specifically stated:

> …a certification submitted by the Secretary of the Navy in writing to the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives that the Navy has within the fleet an operational surface fire-support capability that equals or exceeds the fire-support capability that the *Iowa* class battleships listed on the Naval Vessel Register pursuant to subsection (a) would, if in active service, be able to provide for Marine Corps amphibious assaults and operations ashore.[500]

There is inconsistency between current actions, 1999 Navy statements to GAO, and the 1996 Defense Authorization Act's requirement for "operational fire support capability" prior to striking the ships. It appears that congress merely repealed the 1996 statute, paving the way for the Navy to strike the ships without having to comply with the original intent of the law to have a replacement capability active in the fleet.

Battleships still available: Some members of Congress remain concerned with the lack of naval fire support. The recent House Armed Services committee report on the 2007 National Defense Authorization Act contained specific instructions to the Navy to maintain the USS *Wisconsin* and USS *Iowa* and their infrastructure.[501] The House-Senate conference report for the FY2007 National Defense Authorization Act included clarifying language that the ships be available for reactivation.[502]

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499 *Navy is Complying with Battleship Readiness Requirements*, 7.

500 U.S. Congress, *National Defense Authorization Act for Fiscal Year 1996*, 104th Congress, 2nd sess., S. 1124, GPO. 1995, 236.

501 U.S. Congress, *House Committee On Armed Services House Of Representatives Report On National Defense Authorization Act For Fiscal Year 2007* (Washington, DC: GPO, 2006), 68, 193. The report required the Navy to retain all infrastructure and submit a plan to reactivate the ships.

502 See U.S. Congress, *Conference Report to Accompany John Warner National Defense Authorization Act for Fiscal year 2007* (Washington, DC: GPO), 547; The FY2006 Authorization act requires retention of the ships as national assets. "The Secretary of the Navy shall require that the terms of the transfer of a vessel under this section include a requirement that, in the event the President declares a national

> The House report accompanying H.R. 5122 (H. Rept. 109–452) of the National Defense Authorization Act for Fiscal Year 2007 contained an item of special interest to clarify instructions to the Navy regarding the transfer of the battleships USS Wisconsin and USS Iowa, included in the National Defense Authorization Act for Fiscal Year 2006 (Public Law 109–163). The conferees understand that: (1) the Navy will require that the USS Wisconsin and USS Iowa be preserved in their present condition through continued use of cathodic protection, dehumidification, and other methods as needed; (2) any alterations to the battleships while in the custody of entities within the Commonwealth of Virginia and State of California, respectively, could be reverted; and (3) spare parts and unique equipment, such as 16-inch gun barrels and projectiles, if donated, will include a provision in the donation agreement that they can be recalled if the battleships are returned to the Navy in the event of a national emergency. [503]

This indicates these ships are still considered available for reactivation and modernization by the U.S. Congress.

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emergency pursuant to the National Emergencies Act (50 U.S.C. 1601 et seq.), the transferee of the vessel shall, upon request of the Secretary of Defense, return the vessel to the United States and that, in such a case, unless the transferee is otherwise notified by the Secretary, title to the vessel shall revert immediately to the United States." See U.S. Congress, *National Defense Authorization Act for Fiscal Year 2006, 109th Congress, 1st sess., H.R. 1815* (Washington, DC: GPO, 2005), 288.

[503] *Conference Report to Accompany John Warner National Defense Authorization Act for Fiscal year 2007,* 547.

Appendix H
Background material for Chapter 8 recommendations

Each of the five courses of action identified in Chapter 8 is assessed against nine Risk Assessment Categories. The Courses of Action (COA) briefly are as follows: COA #1 assesses one CVN and seven DDG-1000 and COA #2 assesses two CVN and twenty-four DDG-1000. COA#3, COA #4 and COA #5 all have seven DDG-1000 ships, and in addition, COA #3 has four fire support ships built on commercial hulls. COA #4 has four CSW. COA #5 has four CSW plus two modernized battleships that are decommissioned when the first two CSW when they enter the fleet. A modernization and reactivation cost of $2.74 billion for the two battleships is as outlined in Chapter 7. The evaluation approach to the categories is described below.

The risk assessment categories Near-Peer Competitor (post 2020) and Regional Competitor (before 2012) are qualitative based upon how soon the each COA provides ships to the fleet to challenge the opponent with a significant increase in firepower. These rankings also assess if the COA also provides a robust NSFS capability. A ranking of four or three assumes a significant increase in capability and availability in the proper amount of time. The rankings are qualitative and are informed by the FireSim XXI simulation results which indicate a need for sixteen or more DDG-1000 ships to equal the firepower potential of four CSW.

The risk assessment category Survivability is a qualitative assessment against the DDG-1000, the commercial hull fire support ship and a CSW which is assumed to be a very hard platform similar but better than an *Iowa* class ship. In this case, the CSW's earn a four, the seven DDG-1000 ships earn a one and the twenty-four DDG-1000 ships earn a three based upon large numbers of ships and an additional aircraft carrier to protect them. That is a very rough assessment that is clearly open to other interpretations.

The risk assessment category Gain Operational Experience is a qualitative assessment based upon having ships available in the fleet to gain employment experience before the near-peer competitor appears. The fire support ship is assumed to "just enter" the fleet with all four ships by the time the near-peer competitor presents a challenge.

The risk assessment category Effectiveness (penetration/lethality) is a qualitative assessment based upon known penetration capabilities of major caliber guns. A major caliber gun earns a four, course of action one earns a two based upon limited penetration capability of air weapons. Only a two or four are awarded.

The risk assessment category Effectiveness (volume fires) is a quantitative assessment based upon magazine capacity in table A-31. The maximum number of individual munitions carried by four CSW's is the baseline for a ranking of four. The CSW is assumed to carry at least as many munitions as an *Iowa* class ship.

Munitions	Magazine Capacity	Percent of COA #2	Ranking
COA 1	6,600	-56.0%	1
COA 2	15,000	0.0%	2
COA 3	25,600	70.7%	4
COA 4 & 5	25,600	70.7%	4

Table A-31: Effectiveness (Volume Fire) measured by magazine capacity.

The risk assessment category Construction Cost is a quantitative assessment based upon the construction costs outlined in Chapter 7 and Appendix E. All COAs include construction costs for seven DDG-1000 ships.

Construction	Construction Cost ($B)	Percent of COA #2	Ranking
COA 1	$43	-64.2%	4
COA 2	$120	0.0%	1
COA 3	$40	-66.7%	4
COA 4	$78	-34.8%	3
COA 5	$81	-32.5%	3

Table A-29: Construction Cost ranking.

The risk assessment category Cost (operations and support) is a quantitative assessment based upon information outlined in Chapter 7 and includes an estimate for

DDG-1000 support costs as roughly equal to a DDG-51 class ship as cited in Table 24 on page 80 of this study. A rating of 30 percent or less than COA #2 earns a four.

O&S Costs	Operations and Support Cost ($M)	Percent of COA #2	Ranking
COA 1	$922	42.2%	2
COA 2	$2,184	100.0%	1
COA 3	$414	19.0%	4
COA 4 & 5	$610	27.9%	4

Table A-30: Operations and Support Cost ranking.

The risk assessment category Manpower requirement is a straight forward ranking based upon size of crews. There are seven DDG-1000 ships in all five courses of action. The crew size of the CSW is estimated to be about 900 and the fire support ship is documented at 500 in Chapter 5. The ranking of four is assigned to COA's with 40 percent or less from COA #2. The 40 percent criterion for a ranking of 4 provides recognition that the majority of the crew (manpower) requirement in COA #1 is for the 12th aircraft carrier. COA #3, #4, and #5 garner three capitol ships as opposed to one, therefore justifying a higher ranking between those COAs and COA #1.

Crew Size	Crew Size Requirement	Percent of COA #2	Ranking
COA 1	6,650	44.9%	3
COA 2	14,800	100.0%	1
COA 3	3,050	20.6%	4
COA 4 & 5	4,650	31.4%	4

Table A-28: Crew Size ranking.

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Interviews and/or technical support: Each of these people provided willingly of their time and knowledge. Materials gained from interviews (conducted via telephone) used in the preparation of this study were confirmed with the interviewee via e-mail prior to use. Basic interview dates are listed at the end of each vita.

Clark, CDR Robert, OPNAV N815, Navy Futures Branch; A nuclear qualified submarine officer with service on the USS *Alabama* (SSBN-731) (Gold) and the USS *Georgia* (SSBN-729). Since December 2004 he has served on the staff of the Chief of Naval Operations (Analysis, Programming and Integration). During this assignment participated directly in the JCIDS process by overseeing the staff management and functional analysis process

for the Initial Capabilities Document for "Joint Fires in Support of Expeditionary Operations in the Littorals". Interviewed 21 November 2006 and 16 January 2007

Doran, Thomas; Served at the Naval Surface Warfare Center, Dahlgren Division, from 1978 until his retirement in 2005. He was the 155mm Advanced Gun System Technical Engineering Manager, Extended Range Guided Munition (ERGM) Project Manager, and 16-inch ammunition Project Manager which included the long-range EX-148 13-inch sabot, and upgrades to the 16-inch submunition projectile. Served on the Navy Technical Investigation of the USS *Iowa* (BB-61) explosion and led the Dahlgren Technical Investigation Team. He holds a Masters Degree in Mechanical Engineering from Louisiana State University. Interviewed 23, 25, 31 October 2006; 9 November 2006; 8, 11, 14 December 2006, and 13 February 2007.

Edwards, James B. From 1965 to 1968 started and managed the Navy's "Gunfighter" long-range gun program. "Gunfighter" developed both a 40 nautical mile range fin-stabilized, sub-caliber round for the 8-inch/55 caliber gun and a 50 nautical mile range 280-mm spin-stabilized, sub-caliber round for the 16-inch/50 caliber gun. Gunfighter also conducted studies of a family of full-bore, rocket-assisted, fin-stabilized, guided projectiles with ranges in excess of 100 nautical miles for the 8-inch/55 caliber and 16-inch/50 caliber guns. Interviewed 21-24 November 2006 and 21 March 2007.

Herndon, Robert B., Lieutenant Colonel, U.S. Army Capabilities Integration Center (ARCIC); Fire Support Officer for 2d Brigade, 10th Mountain Division during Operation Anaconda, Fires and Effects Coordinator for Coalition Joint Task Force (CJTF) Mountain, and Chief of Operations for CJTF 180, all in Afghanistan. Since September 2004, has served as ARCIC Fire Support Branch Chief, responsible for integrating Fire Support capabilities into current and future Army Modular Force and action officer representing the Army in "Joint Fires in Support of Expeditionary Operations in the Littorals" working group. Interviewed 15-18 August 2006; 12 Sept 2006; 5, 13 October 2006; 5, 16-17 January 2007.

Kelley, Paul X., General, USMC (retired): served as the 28th Commandant of the Marine Corps and Member of the Joint Chiefs of Staff from 1983 until his retirement in 1987. He commanded Marine Corps organizations at every echelon from platoon through division, including an infantry battalion and infantry regiment during two combat tours in the Republic of Vietnam. In 1979, he was appointed by the President as the first Commander of the Rapid Deployment Joint Task Force, and spearheaded its re-designation as the U.S. Central Command. He remains the youngest Marine to be promoted to the rank of General, and is a Marine Corps Parachutist, Army Master Parachutist and Navy SCUBA Diver. Interviewed 12-15 and 20 February 2007.

Morison, Samuel Loring; A freelance journalist, naval historian and researcher who has spent over forty years studying and writing about the U.S. Navy and naval warfare. In addition he spent 13 months in Vietnam (1967/1968) seeing combat during that period. Grandson of the late renowned U.S. Naval Historian Rear Admiral Samuel Eliot Morison, he has produced 8 books and over a hundred articles. Interviewed 7 November 2006.

Myers, Charles E.: Former Director for Air Warfare, Office of the Secretary of Defense (1973-78) where he launched Project Harvey, later known as the "Stealth" program and oversaw programs such as F-16, F-18, A-10, AV8B, Advanced Sparrow, Sidewinder, HARM, IR Maverick, Laser Guided Bombs and AMRAAM. In 1978 he began an effort to reactivate *Iowa* Class battleships, meshing with his Littoral Warfare study, which illuminated the

need for a "fire support ship". Chuck completed both Army Air Corps and Navy pilot training. In WWII he flew Army B-25 low-level attack missions in the Pacific Theater. After the war he attended Lafayette College (BS in ME). Later, commissioned as a Naval Aviator, he flew F9F Panther jets from the USS *Bon Homme Richard* in the Korean War. He graduated from the Navy Test Pilot School in 1954 and later served as an experimental test pilot at EAFB. He was inducted into the Virginia Aeronautical Historical Society's Hall of Fame in 1999. His current project is exploring the military utility of LTA "hybrid aircraft" under contract to NAVAIR for the Joint Chiefs of Staff. Interviewed 1-6 March 2007.

Reilly, Dennis; Earned a Ph.D. in plasma physics from the University of California Berkley, following which he pursued defense research for 21 years at Avco Everett Research Laboratory, retiring as Chief Scientist. More recently, working for his own company, PPF Research, he has investigated a robust, non GPS dependent, means for precision guidance, and in collaboration with Pratt & Whitney Corp., a gun launched, scramjet propelled projectile with unprecedented range. Interviewed 18 October 2006; 9, 14 December 2006, 3 January 2007 and 6 March 2007.

Schires, Brian G., Captain (USN, Retired); Vice President of Whitney, Bradley & Brown, Inc., providing analytic support to the Initial Capabilities Document for Joint Fires in Support of Expeditionary Operations in the Littorals. Career Navy surface warfare officer, served aboard six surface combatant warships and commanded two cruisers. Head, Land Attack Warfare Branch (OPNAV (N86)) responsible for the development of land attack warfare weapons systems to include the Navy's new *Zumwalt* Class multi-mission destroyer, DDG 1000. Interviewed 5, 8, 14 December 2006.

Sullivan, Robert; An operations analyst at the Center for Naval Analyses (CNA), served as lead analyst for the 1993-1994 Naval Surface Fire Support Cost and Operational Effectiveness Assessment (NFSF COEA). He has worked as a CNA analyst for 25 years, during which time he has worked primarily in anti-air warfare, anti-surface warfare, amphibious warfare, and command and control. Prior to coming to CNA, he studied physics at CalTech and the University of California. Interviewed 2-3, 6-8, 14 November 2006, 28 March 2007.

Train, Harry D. II, Admiral, USN (retired): A Senior Fellow at the Joint Forces Staff College, he has recently retired from Science Applications International Corporation (SAIC) as Hampton Roads Operations Manager. He has served as NATO's Supreme Allied Commander, Atlantic before its transformation to Allied Command, Transformation and as Commander-in-Chief of the U.S. Atlantic Fleet and the U.S. Atlantic Command before its transformation to the U.S. Joint Forces Command. His operational commands have included the U.S. Sixth Fleet in the Mediterranean, the John F. Kennedy Carrier Battle Group, the guided missile destroyer USS *Conyngham* and the attack Submarine USS *Barbel*. He has also served as the Director, Joint Staff and Director of the Systems Analysis Division of the Navy Staff. During his mid-shipman cruise he served as a 16-inch gun pointer on the USS *Washington* (BB-56). Interviewed 30 April 2007; 1-4 May 2007.

van der Schroeff, Coenraad, Captain (USN, Retired); A career Navy Surface Warfare Officer with service on seven warships, including command of the cruiser USS *England* (CG 22) and the USS *Wisconsin* (BB-64). Significant assignments ashore included Head, Combat Systems and Missile/Gun Department at the Naval Ship Weapon Systems Engineering

Station, Port Hueneme, Branch Head for Anti Air Warfare, OPNAV, and Director, Test and Evaluation Division, under the Director Test and Evaluation and Technology Requirements in the Office of the Chief of Naval Operations. Currently with the Boeing Company managing Ground-based Missile Defense European Site development for Advanced Programs. Interviewed 27 September 2006 and 3 January 2007.

Zimm, Dr. Alan; A Principal Professional Staff member at Johns Hopkins University's Applied Physics Lab (JHU-APL). He holds a doctorate in operations research and is a retired nuclear power qualified surface warfare naval officer. At APL, Dr. Zimm has performed DD(X) design trade studies, Advanced Gun System trade studies and effectiveness analyses, trade studies employing Naval Surface Fire Support in an expeditionary warfare context, studies on Maneuver Warfare doctrine, and mathematical modeling of economic social systems. The majority of the naval fire support efforts have been in direct support of the Department of the Navy. Interviewed 17-19 October 2006; 5-8 December 2006; 22 February 2007; 7, 21-22, 25 March 2007.

FireSim modeling support: FireSim XXI was designed and built by the United States Field Artillery School and Center and is the fundamental model for all field artillery fire support training, experimentation and studies. It is an event-sequenced, stochastic simulation of opposing Artillery forces. These forces include aviation, missile and naval fire support capabilities FireSim XXI can use scenarios built in-house or a previously gamed scenario from another model such as Vector-in-Commander (VIC) as a driver. This simulation models the target acquisition, communications, weapons/target allocation, and artillery firing in detail in a dynamic scenario. FireSim XXI may be executed in either DIS or closed analytical mode. FireSim XXI is a research and evaluation tool used primarily to analyze the relative differences between competing indirect fire systems, such as target acquisition sensors, automated tactical data systems, ammunition, and ammunition delivery platforms, within various arrangements of core structures. Terrain and vegetation may be played either statistically or directly using Compact Terrain Data Base (CTDB) format. The Proponent Agency is the Commander, U.S. Army Field Artillery School and Center, ATTN: Fires Battle Lab Simulations Division, Fort Sill, OK 73503-5600.

Niederhauser, LTC Chris; A career Army Aviation and Simulations Officer, he currently serves as Chief of Simulations for the Army Fires Center of Excellence, Fires Battle Lab. He is the configuration manager for the FireSim XXI field artillery simulation and is responsible for the oversight of the development and use of the FireSim XXI model. Through a Scientific Engineering and Technical Assistance (SETA), Tec-Masters Inc. assists with model development at the Fires Battle Lab. Interviewed 26 October 2006; 21-22 November 2006 and 8-9 March 2007.

Quensel, Susan; A retired career Army engineer and Operations Research Systems Analysis (ORSA) officer who now serves as Senior ORSA with TecMasters, Inc., conducting fire support simulations using the FireSim XXI model for Fort Sill and the Center for Army Analysis. She was Chief analyst for the Joint Geospatial Enterprise System Analysis of Alternatives as certified by the U.S. Army Training and Doctrine Command. She has over 20 years of ORSA experience, with many published reports and scholarly works and holds a Masters of Science in Operations Research and Systems Analysis from the Naval Post Graduate School. Interviewed 7-11, 15-18, 27-30 November 2006; 4-5, 7-8, 14-15 December 2006; 9-10 January 2007; 13-16, 29 March 2007.

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Vita

Colonel Shawn Welch was commissioned a Second Lieutenant, Corps of Engineers, in June 1984. He has served in engineer troop unit assignments from platoon through group staff level. His first assignment after completing the Engineer Officers Basic Course was as a combat engineer platoon leader in Bravo Company, 1st Engineer Battalion, 1st Infantry Division. He has served as a company commander in the 1st Engineer Battalion (acting), the 276th Engineer Battalion of the Virginia Army National Guard and the 3rd Battalion (Officer Candidate School), 11th Infantry Regiment, of the Infantry School at Ft. Benning Georgia. During his service as a traditional National Guard soldier (1989-1994), he was employed as a Field Engineer in the commercial construction industry within the metropolitan Washington D.C. area. He returned to active service in the National Guard Title 10 Active Guard Reserve program in 1994. His previous assignment prior to attendance at the Joint Advanced Warfighting School was as the Deputy Chief, Command and Installations Program Analysis Division, Army Program Analysis and Evaluation Directorate (PAED), G-8, Headquarters Department of the Army Staff.

Shawn's interest in Artillery and fire support is long standing. Beginning as an Infantry Task Force Engineer in the 1980s, he learned first hand the impact of Artillery during major training exercises. As an avid historian, he serves on the Board of Directors of a non-profit historic preservation, restoration and interpretation corporation.

Shawn is married to the former Diane Elizabeth Buckman. They have three adult children, and are patiently awaiting grand children.